THE CARL MOYER MEMORIAL AIR QUALITY STANDARDS ATTAINMENT PROGRAM GUIDELINES

PROPOSED REVISIONS 2003

March 2003

California Environmental Protection Agency

Air Resources Board

In memory of Dr. Carl Moyer
(1937 - 1997)

This program is named in honor of the late Dr. Carl Moyer, whose extraordinary dedication, hard work, vision and leadership made this program possible. He created and masterminded this program, in a noble effort to unite business and government in the name of public interest to improve California's air quality.

This update was a collaborative effort and has benefited from the valuable contributions of the participating air districts. The ARB appreciates the considerable efforts of district staff both in the development of these guidelines as well as the day-to-day implementation of the Carl Moyer Program.

EXECUTIVE SUMMARY

The Carl Moyer Memorial Air Quality Standards Program (Carl Moyer Program or CMP) is a grant program that funds the incremental cost of cleaner-than-required engines and equipment. Public or private entities that operate eligible engines and/or equipment in California can participate by applying directly to their local air pollution control or air quality management districts (districts). Examples of eligible engines and equipment include heavy-duty on-road and off-road, marine, locomotive, stationary agricultural pumps, forklifts, airport ground support equipment, and heavy-duty auxiliary power units.

The Carl Moyer Program provides funds for significant near-term reductions in emissions of oxides of nitrogen (NO_X), a smog-forming pollutant. These reductions are necessary for California to meet its clean air commitments under the State Implementation Plan (SIP) and for air districts to meet commitments in their conformity plans, thus preventing the loss of federal highway funds for local areas throughout California. The program also provides reductions of particulate matter (PM) emissions, which are a component of diesel engine exhaust and have been identified as a toxic air contaminant.

The Air Resources Board (ARB or the Board) is responsible for developing the guidelines that districts use to implement the program. The ARB also develops an allocation of the funding to the districts. The California Energy Commission (CEC) has played an important role in the past for infrastructure and technology development.

In the first year of implementation (1998/1999), demand for the $25 million allocation was far in excess of available funding and the resulting emission reductions were extremely cost-effective. As a result, the Governor and the Legislature responded to the program's initial success by awarding one-time budget appropriations of $23 million, $50 million, and $16 million over the next three years in order to continue the program. Total program funding for the first four years was approximately $114 million. In this fiscal year (2002/2003), Proposition 40 - California's Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act (Public Resources Code section 5096.650) -has provided $19.5 million for projects at the local district level that "affect air quality in state and local parks and recreation areas" in accordance with CMP guidelines. Additional funding under the Proposition 40 initiative for fiscal year 2003/2004 will be provided, pending legislative budget approval.

In the second year of the Carl Moyer Program, legislation established a 13-member Advisory Board (Health and Safety Code section 44297 et seq.) with the responsibility for making recommendations on the need to continue the program, the amount and source of continued funding, and program modifications, if necessary. The Advisory Board recommendations included *i*) the continuation of the CMP with increases in funding through the year 2010; *ii*) a cap in local district matching funds consistent with requirements at the $25 million funding level; and *iii)* a statewide 25% PM reduction target and a 25% PM reduction local program requirement for districts in serious non-attainment of the federal PM10 standards. Many of the recommendations of the Advisory Board have since been implemented through legislation or CMP guidance updates. Although no permanent funding has been established at the levels hoped by the Advisory Committee, the CMP has provided some continued level of funding for the last five years.

In the first three years of the CMP, funded projects reduced NO_X emissions by more than 11 tons per day (tons/day) at an average cost-effectiveness of approximately $4,000 per ton of NO_X reduced [ARB March 2002]. This cost-effectiveness compares favorably to other air pollution control programs in California. Project lifetimes range from five to 20 years depending on the type of project. Thus, the program offers necessary and cost-effective near and long-term emission reduction benefits.

The ARB approved the initial set of guidelines for the Carl Moyer Program in February 1999. The first revision of these guidelines was generated and approved by the ARB in November 2000. This proposed set of guideline revisions incorporates a revised allocation of funding and an updated cost-effectiveness threshold as well as codification of existing environmental justice requirements. A number of technical updates are also made throughout the guidelines (e.g., reflecting new emission standards, new emissions inventory models, etc.). The new guidelines ensure that emission reductions remain real, quantifiable, enforceable, and surplus.

All other portions of the current guidelines not explicitly addressed in this document will remain in effect and unchanged. Fundamentally, emission reductions eligible for CMP funding shall not be required by any regulation, memoranda of understanding/agreement, or any other legally binding agreement. These guidelines, which apply to fiscal year 2002/2003 and later, offer local districts the framework for administering their local programs and eligibility criteria for projects.

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INTRODUCTION

The Carl Moyer Program continues to seek near-term reductions of heavy-duty engine emissions to help California meet its air quality obligations under the SIP. The program offers critical emission reduction benefits needed to achieve health-based air quality standards. Through this program, local districts provide grants to public and private entities for the incremental capital cost of cleaner-than-required engines and/or equipment that have traditionally been powered by diesel engines. In the 2002/2003 fiscal year, Proposition 40 offers $19.5 million to be allocated to participating districts for this program. Local air districts that choose to participate in the program may apply to ARB for funds. Presently, CMP guidelines approved by the ARB in November 2000 govern program implementation [ARB 2000]. The revisions described in this report will be applicable for the 2002/2003 and later fiscal years.

Since inception of the CMP in 1998, more than $100 million has been distributed to local districts for clean air projects. In the first year of the program (FY1998/1999), ARB distributed $24.5 million for projects among 16 local air districts, with demand greatly exceeding funding available. Forty percent of those funds went to alternative fuel on-road projects, 25% to marine vessel projects, 20% to agricultural irrigation pumps, and the remaining 15% to forklifts and a variety of off-road diesel re-powering projects.

In June 1999, Governor Davis and the Legislature approved a one-time budget appropriation of $23 million to fund the second year of the CMP (FY 1999/2000). From these funds, ARB distributed $18.62 million to 20 local districts for projects and $4 million to the CEC for infrastructure and advanced technology development.

In October 1999, Governor Davis signed AB 1571 formally establishing the framework for the Carl Moyer Program into the Health and Safety Code section 44275 et seq. In accordance with the Health and Safety Code, ARB developed and presented a report to the Governor, Legislature, and the CMP Advisory Board on the progress of program implementation. In addition, the Advisory Board, with the assistance of ARB, CEC, and the local air districts, developed its own report that included specific recommendations to the Governor and Legislature [ADVISORY BOARD 2000]. Primarily, the Advisory Board recommended continuation of the program through 2010 at a funding level of $100 million per year. Subsequently, the Governor and Legislature approved a one-time appropriation of $50 million to fund the third year of the CMP (FY 2000/2001). From these funds, ARB distributed approximately $43.7 million to local districts for projects and $5 million to CEC for infrastructure and advanced technology projects. The accomplishments of the Carl Moyer Program during its first three years in existence have been described in detail by ARB in its status reports [ARB March 2002].

The Advisory Board, in March 2000, recognizing the challenges for local air management districts to meet cost sharing requirements, recommended to the

Governor and the Legislature that matching requirements for FY 2000/2001 and later be capped at a level equivalent to the first-year funding level. The Governor and the Legislature responded by modifying the statute to allow ARB to modify a district's matching fund requirement if an adjustment is necessary in order to maximize the benefits provided by the program.

In the past, CMP funds have been distributed among participating districts based on two criteria, attainment status of the federal ozone standard and population. Allocations for districts with non-attainment status were determined based on Measure 4 (M4) commitments contained in the SIP and population. For districts in attainment, allocations were determined solely on population. For the first year of Proposition 40 funding (2002/2003), ARB proposes that allocations follow the same methodology based on attainment and population.

SUMMARY OF GUIDELINE REVISIONS AND CLARIFICATIONS FOR 2003

Staff is proposing revisions to the guidelines which include:

1) New district matching fund requirements and tentative funding allocations;
2) Cost-effectiveness update to allow for cost-of-living increase;
3) Meeting matching requirements with PM emission reduction projects;
4) Environmental justice requirements;
5) Update of engine emission standards and emission inventories;
6) Consideration of projects not included explicitly in the existing guidelines;
7) Guidance for engine repower installations; and
8) Reporting requirements for participating local air districts.

These revisions are further described below. All other portions of the current guidelines not explicitly addressed in this document will remain in effect and unchanged. Specifically, emission reductions – NOx, PM, and other pollutants - eligible for CMP funding shall not be required by any regulation, memoranda of understanding/agreement, or any other legally binding agreement.

Districts may fund only those projects that meet the CMP guidelines and eligibility criteria, or those projects approved on a case-by-case basis by ARB's Executive Officer. For projects which are consistent with the guidelines and eligibility requirements, districts may select projects based on local priorities; on a first come, first served basis; on cost-effectiveness; or a combination of these items. Additional criteria may include credit in the evaluation process for projects within environmental justice areas, with direct benefit to local recreation areas and parks, or those that yield both NOx and PM emission reduction benefits. More stringent eligibility requirements may include project funding caps or numerically lower cost-effectiveness. Districts must continue to monitor funded projects to ensure emission reductions are realized over the life of the project. For this, districts must include contractual provisions that legally require grantees to repay funds in the event the contract deliverables are not met.

1) New District Matching Fund Requirements, In-kind Contributions, and Tentative Funding Allocations for FY 2002/2003

Matching fund requirements are important because they provide a literal "buy-in" from local air districts responsible for the selection, monitoring, and enforcement of projects. This requirement also helps ensure that the most worthwhile projects are selected and that more funds are available for clean air projects. For this reason, in the first four years of CMP implementation, a cost share of $1 of local district funds for every $2 of CMP funds was required with a cap consistent with the requirements at the $25 million funding level.

ARB recognizes the new fiscal realities, especially for smaller air districts and the challenges in meeting matching fund requirements. However, as discussed above, staff relies on the match to provide added assurance of the quality of the projects selected and the commitment to audit and enforce these projects. Staff is proposing that local districts receiving only the minimum disbursement may request a one year waiver of the match fund requirement provided they can demonstrate appropriate staff commitment for program implementation and administration. ARB staff will work with district staff to determine the proper level of commitment for a district based on previous history of projects funded and performance. Local district participation in the CMP for the first time will also require district staff training by ARB staff on administration and reporting procedures.

The allocation of funds for fiscal year 2002/2003 is shown in Table 1.1. In determining the allocation, each local air district was eligible for a minimum distribution of $100,000 (as required in the Proposition 40 language). Local air districts with a population equaling or exceeding 1% of the total State population according to U.S. Census 2000 figures or designated federal non-attainment areas with Measure M4 commitments in the 1994 California SIP for Ozone are eligible for additional funds, with equal weight for each factor. Air districts in federal attainment of ozone standards and with populations of less than 1% of the State total will be eligible for the minimum disbursement only.

95% of the State's population is found within the 11 air districts eligible for additional funding. Seven of these districts are designated in federal non-attainment areas with Measure M4 commitments under the 1994 Ozone SIP, and nine of these districts have a population equaling 1% of California's population or greater. For the 11 districts eligible for additional funding, a matching fund requirement of $1 of local funds for every $2 of CMP funds will be required consistent with current guidelines. These match fund requirements shall be determined based on total funding, which includes both the minimum allocation under Proposition 40 and additional disbursements.

Table 1.1. Tentative Local District Allocations for FY 2002/2003.

Carl Moyer Program Funding Allocation Fiscal Year 2002/2003			
Local Air District	**Minimum Allocation**	**Additional Funds (Population and Non-Attainment)**	**Total Funding**
Amador County APCD	$100,000		$100,000
Antelope Valley APCD	$100,000	$158,309	$258,309
Bay Area AQMD	$100,000	$1,678,009	$1,778,009
Butte County AQMD	$100,000		$100,000
Calaveras County APCD	$100,000		$100,000
Colusa County APCD	$100,000		$100,000
Feather River AQMD	$100,000		$100,000
Glenn County APCD	$100,000		$100,000
Great Basin Unified APCD	$100,000		$100,000
Imperial County APCD	$100,000		$100,000
Kern Eastern Desert	$100,000	$137,153	$237,153
Lake County AQMD	$100,000		$100,000
Lassen County AQMD	$100,000		$100,000
Mariposa County APCD	$100,000		$100,000
Mendocino	$100,000		$100,000
Modoc County APCD	$100,000		$100,000
Mojave Desert AQMD	$100,000	$575,375	$675,375
Monterey Bay Unified APCD	$100,000	$181,158	$281,158
North Coast Unified AQMD	$100,000		$100,000
Northern Sierra AQMD	$100,000		$100,000
Northern Sonoma County APCD	$100,000		$100,000
Sacramento Metropolitan AQMD	$400,000	$1,474,808	$1,874,808
San Diego County APCD	$100,000	$717,352	$817,352
San Joaquin Valley Unified APCD	$100,000	$2,879,017	$2,979,017
San Luis Obispo County APCD	$100,000		$100,000
Santa Barbara County APCD	$100,000	$101,809	$201,809
Shasta County AQMD	$100,000		$100,000
Siskiyou County APCD	$100,000		$100,000
South Coast AQMD	$100,000	$7,510,628	$7,610,628
Tehama County APCD	$100,000		$100,000
Tuolumne County APCD	$100,000		$100,000
Ventura County APCD	$100,000	$586,384	$686,384
TOTAL	**$3,500,000**	**$16,000,000**	**$19,500,000**

Note: The Sacramento metropolitan district manages CMP implementation for other districts within its basin: Placer, El Dorado, and Yolo-Solano districts.

Districts will continue to be required to meet matching fund commitments on a program, rather than a project basis. The funding levels illustrated in Table 1.1 are tentative allocations provided all California air districts opt to participate in the program. Should funds go unclaimed by air districts that decline to participate, ARB will revise these allocations and distribute funds to the remaining air districts following the same criteria described above. Air districts with a matching requirement may continue to use motor vehicle fees or other funds under local authority. In the past, a successful practice by the air districts was to use local funding for infrastructure projects, which are excluded from CMP. Conversely, CMP funds were used for marine, locomotive, and other projects not eligible to receive motor vehicle fee funding. For example, district A has a total allocation of $300,000 in CMP funds. If district A spends $150,000 exclusively of local funds for a qualified LNG truck project, the district has met its match requirement and can spend the entire $300,000 CMP allocation to repower tugboats. Therefore, the new funding is still intended to augment successful existing programs that districts may already have for lower-emission on-road and off-road motor vehicle projects. Districts are required to provide information to ARB in sufficient detail in order to facilitate a determination that match requirements have been met.

Districts with a matching requirement may continue to use up to 15% in-kind contribution in the form of administrative costs to satisfy their match requirement. However, no amount of an air district's allocation may be used to cover administrative costs. When projects other than infrastructure are funded by a district to satisfy matching requirements, they must be CMP eligible projects.

Section 44287(e) of the Health and Safety Code continues to allow port authorities or local governments teamed with an air district to participate in the CMP. For instance, port authorities may involve their own equipment or tenants. In addition, ports or local governments may provide up to 30% of the total required matching funds for a district that receives more than $300,000 in total funding. In contrast, private companies are not allowed to provide funding to a district to meet matching requirements.

Once a district application is approved by ARB, initial disbursements are made in the amount of 10% of total funding for districts receiving more than the minimum disbursement or $100,000 for districts eligible for the minimum allocation. The remaining funds will be disbursed based on need as determined by ARB. When a district eligible for additional funding has contract commitments in place totaling the initial disbursement plus the required matching funds, the district may request a subsequent disbursement from ARB for an additional 10% or more if justified by need. ARB will assess a request for more than 10% of total funding based on potential contracts or other information that may indicate need. Districts must submit proper documentation that may include copies of project contracts (front page and signature page) or district board resolution letter indicating project approval. Issuance of checks is estimated to be three to four weeks from the date ARB receives a request for funding. ARB encourages districts to implement the program quickly and to have all funds obligated via contract within one year. Districts must report project status including specific projects, state fund expenditures, additional funds obligated via contract or contracts in progress, and remaining funds that have not yet been obligated. Any funds not obligated by contract at the end of the fiscal year are subject to reallocation as determined by the interpretation of Proposition 40 by the California Department of Finance.

2) New Cost-Effectiveness to Allow for Cost-of-Living Increases

The program cost-effectiveness requirement of $13,000 per ton of NOx reduced was approved by the ARB in the current set of guidelines in November 2000. Section 44283 of the Health and Safety Code authorizes the Board to adjust the cost-effectiveness limit to reflect inflation. The cost of living in California increases annually according to the Consumer Price Index (CPI). According to the U.S. Department of Labor, the U.S. city average CPI, not seasonally adjusted, has increased approximately 3.4% in 2001 and 1.3% in the first half of 2002 [U.S.DOL 2003]. Thus, ARB has adjusted the cost-effectiveness limits for FY 2002/2003 to reflect a total CPI increase from 2000 to the present of 4.7%. The new cost-effectiveness is $13,600 per ton of NOx reduced applicable for FY 2002/2003 and later.

In addition, the Health and Safety Code requires that the cost-effectiveness be annualized using a time value of public funds. The discount rate of 5% approved by the Board in November 2000 is no longer representative of current returns. The minimum project life under the CMP is 5 years. At present, the annual yield for U.S. Treasury securities with a 5-year maturation is approximately 3.03% [U.S.DOT 2003]. Therefore, the new discount rate is 3% applicable for FY 2002/2003 and later. Cost-effectiveness varies proportionally with Capital Recovery Factor (CRF). The new discount rate results in lower CRF's ranging from approximately 5.5% at 5-year project lifetime to 16% at 20-year lifetime. Thus, the new discount rate improves the cost-effectiveness of a project relative to the current rate.

Carl Moyer Program funding and matching funds may be used to cover the incremental cost of a project up to $13,600 per ton of NOx reduced. Only CMP funding, funding under the district's budget authority, or funding provided by a port authority or local government to meet a matching fund commitment is included in the cost-effectiveness. However, funding for infrastructure projects or private funding used to "buy down" incremental costs above $13,600 per ton of NOx reduced are not included in the cost-effectiveness. The application form in the Appendix offers additional detail regarding the cost-effectiveness calculation.

3) Meeting Matching Requirements with PM Emission Reduction Projects

A new CMP provision offers participating districts with a match fund requirement the ability to use funds under their authority for projects that focus exclusively on PM emission reductions. Funds allocated for PM-only projects can be used to meet matching fund requirements established by the CMP. Possible projects include retrofits for HD diesel trucks or off-road diesel equipment with ARB verified after-treatment systems. Participating districts without a match requirement cannot use their CMP allocations to fund PM-only projects. They must continue to focus on NOx emission reductions. In addition, the cost-effectiveness criterion of $13,600/ ton of NOx reduced required for all CMP projects does not apply for projects focused on PM emission reductions only. ARB staff will work with districts to develop appropriate cost-effectiveness limits for PM. In addition, districts must propose to ARB the intended allocation of their matching funds for PM-only projects in a funding cycle and are subject to ARB's concurrence.

4) Environmental Justice Requirements

State law defines environmental justice as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation and enforcement of environmental laws, regulations, and policies (Government Code section 65040.12). The ARB is committed to making environmental justice an integral part of all its activities. In December 2001, the ARB adopted "Policies and Actions for Environmental Justice" establishing a framework for improving air quality and public health in all California communities, especially in low-income and minority communities. The policy recognizes the need for local air districts to address environmental justice issues at the community level.

AB 1390 (Firebaugh, Stats. 2001, Ch. 763; Health and Safety Code section 43023.5) established environmental justice requirements for the CMP. Beginning in fiscal year 2001/2002, air districts with greater than one million inhabitants must allocate at least 50% of their CMP incentive money in a manner that directly benefits low-income communities and communities of color that are disproportionately affected by air pollution. This currently includes five local air districts: Bay Area Air Quality Management District (BAAQMD), Sacramento Metropolitan Air Quality Management District (SMAQMD), San Diego County Air Pollution Control Districts (SDCAPCD), San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD), and South Coast Air Quality Management District (SCAQMD). Districts with less than a million residents are encouraged to consider environmental justice in allocating CMP funds, to the extent feasible. Some smaller districts have developed environmental justice methodology to implement the CMP. This includes Mendocino County Air Quality Management District (MCAQMD) and Monterey Bay Unified Air Pollution Control District (MBUAPCD).

Proposition 40 (Public Resources Code Section 5096.650), which allocates CMP funds for the fiscal years 2002-2004, reiterates the requirement that environmental justice criteria be considered in determining eligible CMP projects.

Local districts are responsible for identifying affected communities and developing and implementing environmental justice criterion that provides remedies to reduce emissions, exposures, and health risks in their affected communities. Several local air districts have adopted policies and methodologies to determine the areas eligible for targeted funding. The districts have used technical expertise and an in-depth understanding of local issues to develop environmental justice criterion for their communities. The criterion is used to identify disproportionately affected areas and is customized to meet the specific needs of the community.

It is recognized that environmental justice characteristics vary from district to district, depending on the make-up of the community and the pollutants in the area. Generally, local air districts develop disproportionate impact mapping to establish the areas qualified for targeted funding. The criteria developed and used by local districts to establish the maps may include multiple, overlapping factors. This may include, but is not limited to, the following types of criterion: income (below the federal poverty level or income lower than the district average), housing value, tenure of housing (i.e., proportion of rental units), the age of residents (areas with high numbers of children and/or elderly), race, toxic air pollutants, PM exposure, proximity to high traffic areas/transit corridors, etc. Table 1.2 includes the criteria used by air districts to comply with environmental justice requirements.

Table 1. CMP Environmental Justice Criteria Used by Air Districts.

	PM Exposure	Criteria or Toxic Pollutant Exposure	Poverty Level	Communities of Color	Sensitive Population*
Bay Area AQMD	X	X			X
South Coast AQMD	X	X	X		
San Joaquin Valley APCD**			X	X***	
Sacramento AQMD		X	X	X	
San Diego AQMD	X		X		
Mendocino County AQMD			X	X	
Monterey Bay Unified APCD		X	X	X	

* Includes communities with high numbers of children and elderly (newborn to 17 and ≥65 years of age).
** Draft criteria.
*** Criteria may also include migrant farm labor community.

The ARB has identified resources available to assist local air districts in developing environmental justice criterion. Socioeconomic maps denoting poverty level, age, and race are available from the California Energy Commission. The data is based on United States Census information. The Commission staff can develop customized maps based on California air basin and air district. The maps cost about $75 and can be produced in about a week. The Association of Monterey Bay Area Governments (AMBAG) produced the geographic information system (GIS) mapping for the Monterey Bay Unified APCD's program. AMBAG can assist other air districts in developing programs using the Monterey methodology. The cost for this service is approximately $5000, depending on district size, additional work tasks, and GIS data availability. Districts looking to independently develop environmental justice elements can access information from the following sources: local planning and community development departments; the United States Census Bureau; and the California Department of

Housing and Community Development. Additional information, about environmental justice resources, is also available from ARB staff and the CMP website at http://www.arb.ca.gov/msprog/moyer/moyer.htm.

Districts must report the efforts that have been made to comply with environmental justice requirements. Key elements that must be reported include: funding allocated to projects in environmental justice communities; environmental justice characteristics of the community; methodology used to identify disproportionately affected areas; criterion used to select eligible projects; outreach efforts used to reach potential project recipients; and a discussion of the benefits and challenges of implementing the environmental justice program.

5) Update of Engine Emission Standards and Emission Inventories

NOx and PM emission factors have been revised to reflect the most recent information from ARB's emission inventory models, EMFAC2002 and OFFROAD. Emission factors for heavy-duty on-road vehicles are provided for model year and gross vehicle weight rating (GVWR). Furthermore, also updated are the emission factors for off-road, agricultural irrigation pump, and marine engines. Specifically, OFFROAD incorporates the most recent regulations for off-road diesel engines adopted by both the U.S. Environmental Protection Agency (U.S.EPA) and ARB. In the case where new engine standards include NOx and non-methane hydrocarbon (NMHC) limits, guidance is included to establish the NOx fraction of the standard as a function of fuel.

The new guidelines provide for a methodology to include fuel correction factors in emissions calculations to account for the benefits of California diesel fuel. The inclusion of fuel correction factors in the guidelines will align Carl Moyer calculation methodology with the methodology described in ARB's EMFAC2002 and OFFROAD emission inventory models. Specific guidance and examples on how to use fuel correction factors are included in Chapters 2, 3, and 9. Use of fuel correction factors in emissions calculations would be required for diesel engines in other Moyer categories as well.

Under the new guidelines, engines designated for participation in any averaging, banking, and trading (AB&T) program are ineligible to participate in the CMP. This includes off-road engines designated flexibility or family emission level (FEL) engines. Similarly, on-road engines not meeting current standards, but available through non-conformance penalties (NCP) are not be eligible for CMP funding.

6) Consideration of Projects not Included in the Existing Guidelines

Participating air districts are required to observe strict adherence to the ARB-approved guidelines for the CMP. Technologies that offer real and quantifiable emission reduction benefits are fast developing in a number of project categories. On occasion, these technologies fall outside the core project categories of engine replacement, repower, or retrofit projects. Guidance is included in the revised program guidelines to allow for consideration of these unique and innovative technologies. So long as emission reduction benefits are surplus, real, quantifiable, and enforceable, new provisions allow local districts to identify meritorious projects under an “other” category. Districts are required to consult with ARB for final determination of project eligibility. Projects that fall under the “other” category must be evaluated on a case-by-case basis so long as funding is not requested to comply with a regulation or any other legally binding agreement that requires the emission reductions.

One example of a potential category where real emission reductions may be realized is thermal refrigeration units (TRU). Potential applications include purchase of new equipment, repower of TRU’s with either new or newer emission-certified engines, and retrofits such as catalysts and traps. Several types of TRU retrofits produce emission reductions by eliminating the engine run time while the TRU is at a facility. These include electric standby and cryogenic refrigeration systems. Other desirable technologies to offset TRU emissions include alternative fuels, alternative diesel fuels, and fuel cells. Emission factors for engine typical in TRU applications, <11 hp, 11-25 hp, and 25–50 hp, have been included in these revised guidelines (Chapter 10) to facilitate potential evaluation.

7) Engine Repowers

For clarification and in an effort to ensure that emission reductions resulting from engine repowering projects funded under the CMP remain guaranteed for the life of the project by the engine’s original equipment manufacturer (OEM), the use of OEM parts and OEM-authorized dealerships and/or distributors for engine repowers shall be required. In this context, repower also includes remanufacturing and rebuilding of engines. This is consistent with the intent in the November 2000-approved guidelines and the interpretation by most districts.

Furthermore, off-road engine repower installations require the use of technology that meets current Tier 2 standards now in effect for most horsepower (hp) categories. However, ARB recognizes that Tier 2 engines may not be feasible for repower installation on some pre-2002 equipment. The Tier 2 engine support system including electrical, cooling, hydraulics, and engine mounts may not be practically installed. Therefore, the revised guidelines include provisions that may allow engines meeting Tier 1 standards for repower installations when it is the only feasible option. Evaluation will be on a case-by-case basis and districts are required to consult with ARB on each application calling for equipment not meeting current standards.

8) Reporting Requirements for Participating Local Air Districts

An annual report on Proposition 40 expenditures to the Legislature is required. As a result, the Department of Finance, Office of State Audits and Evaluations, will audit program administration at both the state and local levels. ARB’s reports are based on the information provided by all participating districts. Thus, each district will continue to be required to report routinely to ARB following ARB-approved forms and formats. ARB will release specific deadlines and reporting requirements once a district application for funding is approved.

It is anticipated that in the month of July following the end of a fiscal year funding cycle, districts will be required to submit a progress report on their implementation efforts. This initial report must include: 1) an overview of the application and funding allocation process; 2) anticipated sources for matching funds, 3) targeted types of project categories (e.g., 23 trucking firms, 14 warehouse distribution centers, 27 farms), 4) dates and recipients of mailout(s), applicants, 5) names of staff responsible for program implementation; and 6) outreach activities (completed and planned). More detail will be provided to the districts by ARB program staff.

Districts must follow with an annual report to ARB shortly at the end of the fiscal year funding cycle. Minimally, the annual report must include: 1) detail descriptions of projects funded, 2) baseline and incremental project costs, 3) project-specific emission reductions and cost-effectiveness, 4) infrastructure funding for qualified vehicle or equipment projects, 5) total state funding obligated under contract, and 6) total district matching funds obligated, if applicable. Any updates of information included in the annual report must be submitted in a final report approximately a year after the end of a fiscal year for which reporting applies.

<u>Program Milestones</u>

Experience with CMP implementation suggests that it is necessary for both ARB and district staff to follow a consistent schedule to ensure program continuity and smooth project deployment. Thus, the tentative outline of activities and milestones below for year one (FY 2003/2004) is intended to offer some guidance for planning. The schedule repeats for subsequent funding cycles.

February '03 – 4th week	Public release of revised Carl Moyer Program Guidelines for comment.
March '03 - 4th week	ARB hearing to consider proposed revisions to guidelines.
April '03 – 2nd week	District applications due.
April '03	ARB review of district applications.
May '03	ARB initial awards for FY 2002/2003.
	Training of district staff (first time participants)
July '03	District initial report on implementation due. Report on policies and procedures for local implementation including methods of award of funds and parameters of awards (project categories, amount, EJ, etc). Specify any funds that may be obligated.

Aug ’03 – Mach ’04	ARB awards for FY 2002/2003 continue based on need. District implementation plans and applications for FY 2003/2004.
March ’04	District applications due.
April ’04	ARB review of district applications.
April ’04	ARB initial award for FY 2003/2004.
July ‘04	FY 2002/2003 (Year One) district annual report due. Report includes funds obligated, paid, and unpaid.
July ’05	FY 2002/2004 (Year One) district final report. Report on modifications to annual report and final program deployment (projects funded, amounts, emission reductions achieved, cost-effectiveness, cancellations, etc).

ADDITIONAL REQUIREMENTS

Local Districts Retain Ability to Impose Additional or More Stringent Eligibility Requirements - To facilitate program implementation at the local level and ensure that local air districts have the ability to maximize the use of public funds to achieve emission reductions, local air districts will continue to be eligible, and are encouraged to integrate additional or stringer eligibility criteria for program applicants. For example, districts retain the ability to consider only projects submitted by the public agency or private enterprise that owns the motor vehicle(s) and/or equipment to be replaced, repowered, or otherwise modified. Projects submitted by a third party, other than the public agency or private enterprise that owns the motor vehicle(s) and/or equipment to be replaced, repowered, or otherwise modified can be deemed ineligible. In the past, some local districts have opted successfully to maximize the number of projects funded under the program by including funding caps and lower cost-effectiveness criteria. In addition, districts may choose to focus specifically on projects that offer a direct benefit to local parks and recreation areas. This may be accomplished by offering credit in the evaluation for such projects.

New and Updated Examples of Calculations - In response to requests by local air district staff, the revised guidelines document includes more examples of sample calculations to assist in the evaluation of projects. In addition, new examples have been added in anticipation of newer varieties of projects.

PM Emission Reduction Requirements and Goals – Recognizing the need for particulate matter (PM) reductions throughout California, the CMP Advisory Board concluded that projects that offer both NOx and PM emission reduction benefits should be encouraged. Following this recommendation, a goal to reduce PM emissions from funded projects by 25 % statewide was instituted with two exceptions. In areas designated as serious non-attainment of the federal PM10 standard, minimum program-wide PM reductions of 25% are required. San Joaquin Valley Air Pollution Control District (SJVAPCD) and South Coast Air Quality Management District (SCAQMD) are the two districts affected by this requirement.

Districts will continue to be required to meet PM emission reduction commitments or goals on a program, rather than a project basis. PM emission reductions for a specific project are determined based on the applicable emission factors provided in the CMP guidelines. These emission factors are obtained from either ARB's emission inventory models or other approved sources. PM emission reduction evaluations follow the same methodology developed to determine NOx emission reductions. State and local district compliance with the PM reduction goals and requirements is determined by ARB. ARB retains the ability to recommend modifications to a district's program in the event that PM emission reductions fall short of expectation. PM emission reductions are discussed more extensively in Chapter 9.

Incremental "Clean" Fuel Cost – In accordance with statutes, the CMP has allowed the use of incremental "clean" fuel costs for meeting a district's matching fund requirements. Clean fuels include alternative fuels and alternative diesel fuels that have been verified by ARB for emission reductions. Standard gasoline or diesel fuels are excluded. For districts with a matching fund requirement under the guideline revisions, incremental "clean" fuel cost will continue to be allowed to meet such requirements.

NOx Emission Reduction Requirement - After study and public notice and comment, Section 44282 of the Health and Safety Code authorizes ARB to revise the minimum NOx emission reduction requirement for retrofit and repower equipment as necessary and in order for the program to achieve its air quality goals. At present time, a revision of the existing NOx emission reduction requirement is not proposed. Therefore, the requirement for all retrofit and repower projects will continue to be a minimum of 15%.

Repower Funding Caps – Funding caps for off-road repower projects were included initially in the CMP and removed in the last guideline revisions approved in November 2000. This encouraged participation of large off-road and agricultural engine projects with significant potential benefits. Funding caps will continue to be excluded from the present revisions and CMP eligibility will continue to be based on cost-effectiveness. However, this provision does not preclude a local air district from imposing more stringent requirements that may include funding caps if it maximizes the district's ability to reach its air quality goals.

Diesel Hybrids - Heavy-duty hybrid-electric technology have been demonstrated in California to offer significant NOx and PM emission reduction benefits. Manufacturers are currently focusing on the transit bus market. At the time of the November 2000 CMP guidelines, a certification procedure for this technology did not exist. Thus, emission levels were to be determined on a case-by-case basis.

Presently, ARB has approved an interim certification procedure for hybrid-electric urban transit buses [ARB October 2002]. Therefore, eligibility of projects under this category will be evaluated in the context of the new information provided in the approved certification procedure.

Electric Forklift Program – Retrofit and auxiliary technologies verified or evaluated by ARB and that result in emission reductions shall be eligible for CMP funding if they meet all other established project criteria. Finally, for the purpose of CMP eligibility, when a forklift truck operates with alternative attachments other than the conventional double-fork unit, it shall remain eligible under the forklift category subject to the criteria established in Chapter 7.

Diesel-to-Diesel Repowers – Only “pull-ahead” new engines (those meeting 2004 emission standards) and existing late 1990 model year engines that have been reflashed to eliminate off-cycle NOx emissions under the settlement agreement between manufacturers, U.S.EPA, and ARB shall be eligible for repowers under the CMP program. In addition, the local districts will retain discretion to consider mechanical-to-electronic engine repowering if a project is technically feasible and meets all CMP criteria.

STAFF RECOMMENDATIONS

Staff recommends that the Board, at its March 26, 2003 hearing, approve the proposed guideline revisions for the Carl Moyer Program. The guidelines establish the framework for implementation of the program in California. The impetus for the revisions was to integrate into the program updated information and clarifications of previous provisions. The goal of the program continues to be to achieve surplus, real, quantifiable, and enforceable, cost-effective emission reductions. In summary, the Board approval includes,

- New district matching fund requirements that include the opportunity for smaller districts to obtain a one-year waiver of their match as well as updated funding allocations;

- Cost-effectiveness update to allow for cost-of-living increase;

- Incorporating environmental justice requirements into the CMP guidelines that are consistent with the legislative requirements and the environmental justice criteria of the Board;

- Update of engine emission standards and emission inventories for each of the categories;

- Consideration of projects not included explicitly in the existing guidelines upon staff evaluation on a case-by-case basis;

- Guidance for off-road engine repower installations that allow Tier 1 engines to be used only upon ARB approval on a case-by-case basis; and

- Reporting requirements for participating local air districts that include new Proposition 40 requirements.

Chapter Two
ON-ROAD HEAVY-DUTY VEHICLES

This chapter presents the revised project criteria for on-road heavy-duty vehicles (HDV) under the CMP. It also contains a brief overview of the heavy-duty vehicle industry, NOx emission inventory, current engine emission standards, available control technology, potential projects eligible for funding, and emission reduction and cost-effectiveness calculation methodologies.

INTRODUCTION

Vehicles greater than 14,000 lbs gross vehicle weight rating (GVWR) are considered to be HDVs, which can be categorized further as heavy heavy-duty (HHD) and medium heavy-duty (MHD) vehicles. HHD vehicles (e.g. line-haul trucks and urban buses) are those greater than 33,000 lbs GVWR and are grouped under a "Class 8" truck classification. MHD vehicles are those with GVWR's greater than 14,000 lbs, but less than or equal to 33,000 lbs. They comprise Classes 4 through 7 trucks and include most delivery trucks. The majority of all HDV's are powered by compression-ignition (CI) internal combustion engines (ICE) typically fueled with diesel fuel.

This preference for diesel engines presents an air quality challenge since NOx and PM emissions have not decreased to the extent that gasoline-fueled vehicle emission have, particularly for light- and medium-duty vehicles. Furthermore, HDVs involved in the transport of goods typically accrue higher annual mileage than other vehicles. Consequently, the share of total emissions from HDVs is disproportionately higher than their population would suggest. The CMP provides financial incentives for the acquisition of cleaner-than-required HDVs, including urban transit buses.

In California, on-road mobile sources are responsible for approximately 50% of total NOx emissions. Even though the population of all HDVs, including urban buses, accounted for approximately 1% of all on-road vehicles, they emitted nearly 40% of the statewide NOx and exhaust PM emissions from all on-road vehicles in 2002. HDVs vehicles emitted about 630 tons per day (tpd) of NOx and 11 tpd of exhaust PM emissions statewide. In addition, vehicle miles traveled (VMT) by HDVs are projected to increase by about 20 percent by 2010. Clearly, emissions from HDVs diesel vehicles have to be reduced further if air quality goals are to be achieved.

EMISSION STANDARDS

Engine emission standards have progressively and substantially reduced NOx and PM emissions from HDVs over time. NOx emissions from new HDVs will be further reduced by one half starting in 2004 as a result of recently adopted regulations. In addition, a number of heavy-duty engine manufacturers have entered into Settlement Agreements with ARB (under the federal Consent Decree) to correct off-cycle NOx emissions. Part of this agreement required some engine manufacturers to produce cleaner engines meeting 2004 emission standards starting in October 1, 2002. Table 2.1 lists the existing and future NOx and PM emission standards for heavy-duty engines.

Table 2.1. Exhaust Emission Standards for Heavy-Duty Engines.

	NOx and PM Emission Standards (g/bhp-hr)[a]			
	Heavy-Duty Vehicles		Urban Buses	
Model Year	NOx	PM	NOx	PM
1996 - 2003	--	--	4.0	0.05 [b]
1998 - 2003	4.0	0.10	--	--
October 1, 2002[c]	2.4 [d] or 2.5 [e]	0.10	2.4[d] or 2.5[e]	0.05[b]
2004 - 2006	2.4 [d] or 2.5 [e]	0.10	2.4[d,f] or 2.5[e,f] 0.5[g]	0.03[f] 0.01[g]
2007 +	0.2	0.01	0.2	0.01

[a] g/bhp-hr = grams per brake-horsepower-hour
[b] in-use standard of 0.07 g/bhp-hr
[c] These standards are applicable to Settlement Agreements (Consent Decree) engines
[d] NOx plus Non-Methane Hydrocarbons (NMHC)
[e] NOx plus NMHC with 0.5 g/bhp-hr NMHC cap
[f] For Transit Agencies on the Alternative Fuel Path, these standards are applicable to alternative fuel engines
[g] For Transit Agencies on the Diesel Path, these standards are applicable to both alternative fuel and diesel engines; for Transit Agencies on the Alternative Fuel Path, these standards are applicable to diesel engines

As illustrated in Table 2.1, the emission standards for heavy-duty diesel engines have changed in 2002 to a combined NOx+NMHC standard. In the CMP, eligibility is based on the cost-effectiveness of NOx reductions relative to the current baseline NOx+NMHC emissions of 2.5 g/bhp-hr. To determine the NOx fraction from the combined NOx+NMHC values, staff analyzed engine certification data submitted to ARB for both diesel and natural gas (NG) engines. On average, the NOx fraction in the NOx+NMHC certified emission values from diesel engines range from 90% to 98%. In contrast, for NG-fueled engines, the NOx fraction is approximately 80% of the combined NOx+NMHC certified emission values (Table 2.2). To determine NOx emissions, the certification NOx+NMHC emission standard for an engine is multiplied by the appropriate NOx fraction. A different NOx fraction than the default values illustrated in Table 2.2 may be used if justified by proper documentation submitted to ARB for consideration.

Table 2.2. NOx Fraction Default Values.

Diesel Engines	Alternative Fuel Engines
0.95	0.80

OPTIONAL TECHNOLOGIES AND PROGRAMS

Commercially available reduced-emission engines for MHD and HHD vehicles are considered suitable for CMP-funded new engine/vehicle purchases or new engine purchases for vehicle repower opportunities. In addition, emerging technologies that may be commercially available in the near future are likely candidates for the CMP as soon as the engine technology becomes certified in California.

Diesel engines, due to their high efficiency and long life, dominate the MHD and HHD vehicle markets. However, their typical lean-burn, high-compression, high-temperature operation has resulted in technical limitations for achieving significant NOx emission reductions. Alternative fuel engines, especially those fueled by compressed natural gas (CNG) and liquefied natural gas (LNG), have been able to achieve NOx emissions about half of a conventional diesel engine. Dual-fuel engines also exist for HD truck applications. Alternative fuel engines, including liquefied petroleum gas (LPG) engines, are available for MHD truck applications. Engine manufacturers have invested significant resources for the development of reduced-emission diesel engines and progress has been made, especially with the integration of advanced electronics, the use of exhaust gas recirculation (EGR), and aftertreatment. As a result, today's generation of HD diesel engines is nearly as clean as some of the alternative-fuel engines produced prior to 2003. Nevertheless, it is likely that only alternative-fuel engines will meet the lower optional NOx emission standard requirement for CMP funding. This is because technology for alternative-fuel engines has also experienced significant improvement. Therefore, it is expected that alternative-fuel vehicles will continue to be the only choice to meet the requisite emission reductions in the CMP for new on-road HD projects.

The variety of alternative fuel engines available and the number sold in California has increased significantly. However, due to the increasingly stringent optional credit emission standards for model year 2003 and later engines, the number of available alternative fuel engines certified to this credit standard is limited. As engine technology matures, the number and variety of engines certified to the new optional emission credit standards will continue to expand. Alternative fuel vehicles have had the most success in the transit bus market. Presently, approximately 50% of all bus sales in California are alternative fuel vehicles and a significant number of transit agencies have focused exclusively on alternative fuel buses for new purchases. These include the Sacramento Metropolitan Regional Transit Authority, Los Angeles County Metropolitan Transportation Authority, and Sunline Transit.

Dual-fuel engines are available, which yield NOx emissions approximately 40% lower than the required standard. However, in the past, there was a concern that benefits were reduced significantly over low-speed, stop-and-go engine operation. While the alternative fuel substitution rate may have been on the order of 80% during certification testing, the use of alternative fuel was significantly lower over a stop-and-go duty cycle. At present, dual-fuel engines continue to be of interest when adequate alternative fuel usage is ensured in all applications. Consideration will be given on a case-by-case basis by ARB and district staff to ensure that all eligibility requirements are met.

Several low-emission technologies hold promise for the future. These include cooled EGR retrofit, active NOx catalyst, and selective catalytic reaction (SCR) retrofit. Some of these technologies have been verified or are close to achieving verification by ARB for sale in California. In general, technologies are only eligible for participation in the CMP when they are verified by ARB. In the event that a promising technology with demonstrated potential for emission reductions has been evaluated (and not formally verifed) by ARB, an experimental permit would allow the engine technology to operate in California; hence, qualify for the CMP. Experimental permit applications are considered on a case-by-case basis and they are typically granted for demonstrations involving one or two vehicles. Permits include strict limitations such a limited time for operation of the experimental engine and requirements for removal from service, unless an extension is granted. ARB intends experimental permits to be a means for field demonstrations and not a way to circumvent certification requirements. Even though these emerging technologies may not be commercially available during the current funding cycle of the CMP, an on-going incentive program may provide the thrust necessary for development of these and other promising technologies. Long-term options such as fuel-cell or hybrid power plants are candidates for funding under the program after certification or issuance of an experimental permit. However, they would likely require a cost buy-down to meet the cost-effectiveness requirement.

Alternative Diesel Fuels
Over the years, industry has produced alternative diesel fuels such as diesel water emulsions and bio-diesel that lower PM and/or NOx emissions from engines relative to the use of conventional diesel fuel. While some of these technologies are still in the research and/or demonstration stage; others, such as emulsified diesel fuel, are emerging as commercial products in California. Currently, emulsified diesel fuels have been verified by ARB to reduce NOx and PM emissions from unmodified diesel engines. Therefore, ARB is currently evaluating options for inclusion of alternative diesel fuels into the CMP.

The CMP was designed to reduce emissions by enabling engine technologies that have been certified to emission levels better than current standards. In essence, the program buys emission reduction benefits by offering incentives for replacing old diesel engines. In general, engine technology is tested according to established regulatory test procedures, certified by ARB, and sold with OEM warranties. Hence, the program provides surplus, real, quantifiable, and enforceable emission reductions. However, unlike a project that involves the installation of a certified low-emission engine or the use of a retrofit kit, the emission benefits associated with the use of an alternative diesel fuel cease to exist if the fuel is not used. Thus, a key question is enforcement of the use of the alternative diesel fuel over the life of the project. Currently, there is no method for assuring that an alternative diesel fuel is being used over conventional diesel. In addition, the use of alternative diesel fuels moves the CMP from its intended focus on hardware upgrades to a program that would offer incentives for the continued operation of old, high-emitting diesel engines in California. Finally, the CMP bases emission reductions and cost-effectiveness on actual equipment usage (i.e., mileage, fuel consumption, or hours of operation) and the cost difference between engine technologies. In the case of fuels, the difference between the alternative diesel fuel and conventional diesel fuel would be eligible costs for CMP funding. Thus, tracking and monitoring of fuel consumption for the alternative diesel fuel would be required. Therefore, at present time, criteria for alternative diesel fuel projects is not included in these guidelines revisions. Projects will be considered by ARB on a case-by-case basis.

In the past, AB 2061, signed by the Governor, appropriated $500,000 to be used for alternative diesel fuels. ARB developed test procedures to evaluate the emission benefits of alternative diesel fuels. Funding for alternative diesel fuel projects was based on the incremental cost between fuels. Alternatively, funding for alternative diesel fuel could be subject to a cost cap based on the per-unit price of the fuel. Funding for the incremental cost of alternative diesel fuels (if any) will continue to be allowed on a case-by-case basis. However the alternative diesel fuels must be used in a project meeting all CMP criteria. If funded by a district, these funds meet the matching fund requirements under the CMP. In summary, ARB is currently evaluating these programs and approximately $2 million worth of other programs to determine appropriate criteria for long-term implementation.

<u>Alternative Fuels</u>
As in the past, districts continue to have the option to fund only with matching funds the cost difference between conventional diesel fuel and an alternative fuel such as CNG, LNG, and LPG. The fuel purchase must be an integral part of an engine purchase, repower, or retrofit. In addition, cost effectiveness must be based on the total amortized cost of fuel and hardware (i.e., new engine or repower). Therefore, if all CMP criteria are met and the project is not a "fuel-only" project, the incremental cost of alternative fuel is a qualified matching contribution from a district.

<u>Hybrid Electric Vehicles</u>
Hybrid buses utilize an electric drive typically with an IC engine (diesel or alternative-fuel) and a traction battery. Until recently, certification test procedures were based on non-hybrid engine duty-cycles and, therefore, were not able to adequately represent the emissions benefits offered by hybrid technology. At the October 2002 board hearing, the ARB adopted an interim certification procedure for hybrid-electric buses, to be effective for three years. The interim certification procedure is based on a modified version of the Society of Automotive Engineers Recommended Practice SAE J2711. Emissions from hybrid-electric buses are to be determined using chassis dynamometer test results and engine certification values for both the hybrid-electric bus and a conventional drivetrain urban transit bus. In the absence of a final certification procedure for hybrid-electric vehicles, the interim certification procedure for hybrid-electric buses can be used to determine emissions from hybrid-electric vehicles participating in the CMP. Hybrid-electric vehicle projects will be considered on a case-by-case basis.

<u>Incentives for Early Retirement of Pre-1987 Heavy-Duty Vehicles</u>
Pre-1987 heavy-duty diesel trucks still comprise a significant portion of the truck fleet in California. The engines in these trucks are rebuilt periodically since new or newer truck purchases are often cost-prohibitive for the typical truck owner/operator. Traditionally, these vehicles operate on the corridors from California's ports to densely populated areas and in local deliver applications. They may operate around-the-clock and in seasonal transport of agricultural and other products. Thus, there is a clear need to reduce emissions from this segment of the HD diesel vehicle inventory. However, based on analyses conducted by ARB, a statewide heavy-duty vehicle retirement program lacked the expected cost-effective emissions benefits [ARB 2000]. Thus, CMP funding was not allowed for the early retirement of pre-1987 heavy-duty vehicles.

Recently, ARB began exploring the benefits of a focused early retirement program for HDV's. Under certain criteria, such a program could yield quantifiable and enforceable emission benefits. In response to the initiative of the Sacramento Metropolitan Air Quality Management District (SMAQMD), ARB approved the implementation of a pilot program for the early retirement of heavy-duty vehicles, a "Fleet Modernization Program". The criteria of the Fleet Modernization Program were developed by the SMAQMD and intended for HDVs operating within the SMAQMD. In addition, ARB has also approved a similar program for Southern California. This fleet modernization program is administered by Gateway Cities, a coalition of government and private entities tied to HDV transportation at the Port of Long Beach. At present, ARB staff intends to participate and monitor the progress of these pilot programs.

PROJECT CRITERIA

Reduced-NOx on-road heavy-duty vehicle projects, which include new vehicle purchase, vehicle engine replacement (repower), and engine retrofit, can be considered for incentive funding. The project criteria listed below for on-road heavy-duty vehicles provide districts, fleet operators, transit agencies, and applicant with the minimum qualifications for the CMP. The primary criteria for selection are 1) emission reductions, 2) cost-effectiveness, and 3) ability of the project to be completed within the timeframe of the program. Sample calculations that illustrate the methodology for determining emission reductions and cost-effectiveness are included.

- Eligible new vehicle purchase projects must provide at least 30% NOx emission reduction compared to baseline NOx emissions. Baseline NOx emissions correspond to a new engine meeting current applicable emission standards.

- For repower or retrofit projects, the replacement engine or retrofit kit must be certified to reduce NOx emissions by at least 15% and meet all other eligibility criteria as discussed in this chapter.

- NOx reductions obtained through this program must not be required by any existing regulations, memoranda of agreement/understanding, or other legally binding documents.

- If applicable, NOx emission levels shall be determined by multiplying 0.95 to the certified NOx+NMHC emission standard for diesel engines and by 0.80 for alternative fuel engines.

- For diesel engines only, multiply the base NOx emission rate by the appropriate fuel correction factor shown in Table 2.9, in addition to other calculation adjustments.

- Engines designated for participation in any averaging, banking, and trading (AB&T) program are ineligible to participate in the Carl Moyer Program.

- For repowers, engines manufactured after September 30, 2002, that are not certified to the 2.4 g/bhp-hr NOx+NMHC, or 2.5 g/bhp-hr NOx+NMHC with a 0.5 g/bhp-hr NMHC cap, are ineligible to participate in the Carl Moyer Program.

- The newer replacement engine used in vehicle repower projects could be either a new, rebuilt, or remanufactured engine. Eligible rebuilt or remanufactured engines must use OEM components only and be purchased from the original engine manufacturer or its authorized dealers/distributors.

- Reduced-emission engines for repowers or retrofit kits must be certified by ARB for sale in California and must comply with durability and warranty requirements. Qualified engines could include new ARB-certified engines; ARB-certified aftermarket part engine/control devices; or engines with ARB-approved experimental permits.

- Funded projects must operate for a minimum of 5 years and at least 75% of vehicle annual miles traveled must occur in California.

- Projects must meet a cost-effectiveness criterion of $13,600 per ton of NOx reduced.

- The maximum acceptable project life for calculating on-road project benefits is as follows:

	Default without Documentation	Default with Documentation
School buses $\geq$ 33,000 GVWR - New	20 years	N/A
Buses $\geq$ 33,000 GVWR - New	12 years	N/A
Other On-road - New	10 years	15 years
Other On-road - Repowers	7 years	15 years

  A project life that is greater than the “default without documentation” limits may be submitted for approval by ARB.

- On-road HDV projects that fall outside of these criteria may be considered on a case-by-case basis if evidence provided to the air district suggests potential, surplus, real, quantifiable, and enforceable emission reduction benefits.

TYPES OF POTENTIAL PROJECTS

The primary focus of the CMP is to achieve emission reductions from heavy-duty vehicles operating in California as early and as cost-effectively as possible. The project criteria were designed to ensure that the emission reductions expected through the deployment of low-emission engines or retrofit technologies under this program are surplus, real, quantifiable, and enforceable.

New Vehicles

New vehicle purchases of LNG and CNG trucks and buses are expected to continue to be the most common type of project for on-road heavy-duty vehicles under this program, although liquefied propane gas (LPG) continues to be an option. To be eligible, the new vehicle/engine must be certified to one of the ARB's current optional NOx emission credit standards, regardless of fuel type or engine design. Prior to October 1, 2002, the ARB's optional credit standards were based on NOx emissions only. As of October 1, 2002, the optional credit standards are based on NOx+NMHC emissions. The current emissions credit standards start at 1.8 g/bhp-hr NOx+NMHC and decrease in 0.3 g/bhp-hr increments. Engines not certified to the ARB's NOx+NMHC emission credit standards are not eligible to participate in the CMP. Table 2.3 lists the current heavy-duty engines that have been certified to the ARB's optional NOx+NMHC, or NOx for engines manufactured prior to October 1, 2002, emission credit standards. Since new engines are certified throughout the year, districts are encouraged to contact ARB for a most current list of eligible engines.
As evident from Table 2.3, only alternative fuel engines are currently certified to ARB's optional NOx emission credit standard. The CMP continues to be fuel neutral for all project categories. Purchases of new transit buses must be beyond the requirements of ARB's Urban Transit Bus Rule. Thus, applicants must submit evidence of compliance with the fleet rule or documentation to support that CMP funds will not be used to meet fleet rule regulatory requirements.

The NOx and NOx+NMHC values shown in Table 2.3 represent the certification optional credit emission standards. The ARB certifies engines destined for sale in California and provides the engine manufacturers with an Executive Order (EO) for each certified engine family. An example of an EO is shown in Figure 2.1. The EO includes general information about the certified engine such as engine family, displacement, horsepower rating(s), intended service class, and emission control systems. It also shows the applicable certification emission standards as well as the average emission levels measured during the actual certification test procedure. For the purpose of the CMP, the certification emission standards are used in calculating emission benefits. The certification emission standards are shown in the row titled "(DIRECT) STD" under the respective "FTP" column headings for each pollutant. For instance, the Cummins 8.3 liter NG engine illustrated in Figure 2.1 was certified to a NOx+NMHC emission standard of 1.8 g/bhp-hr, a CO emission standard of 15.5 g/bhp-hr, and a PM emission standard of 0.03 g/bhp-hr.

In the case where an EO shows emission values in the rows labeled "AVERAGE STD" and/or "FEL", the engine is certified for participation in an AB&T program. AB&T engines are not eligible to participate in the CMP since emission benefits from an engine certified to a low Family Emission Limit (FEL) are not surplus emissions. They are claimed by the AB&T program and used to offset the emissions from another engine certified to higher FEL levels.

Table 2.3. Heavy-Duty Engines Certified to ARB's Optional NOx or NOx+NMHC Emission Credit Standards.

(Emission Levels for NOx, NOx+NMHC are in g/bhp-hr, and PM are in g/mile)								
MY	Manuf.	Service Type [a]	Fuel Type	Displ (ltr)	Certified Standards		PM[c] g/mi	HP
					NOx	NOx+NMHC[b]		
2003	Cummins	UB	CNG/LNG	8.3		1.8	0.025	250/275/280
2003	Cummins	MHD	CNG/LNG	8.3		1.8	0.06	250/275/280
2003	Cummins	MHD	CNG/LNG	5.9		1.8	0.06	195/200/230
2002	Baytech	HDG	Dual[d]	5.7	1.5		--	211/245
2002	Baytech	HDG	CNG	5.7	1.5		--	211
2002	Cummins	MHD	CNG	8.3	2.0		0.06	250/280
2002	Cummins	UB	CNG	8.3	2.0		0.025	250/280
2002	Cummins	MHD	CNG	5.9	2.5		0.06	150/230
2002	Cummins	MHD	LPG	5.9	2.5		0.06	195
2002	DDC	UB	CNG	8.5	2.0		0.025	275
2002	DDC	UB	CNG	12.7	2.5		0.025	330/440
2002	Deere	UB	CNG	8.1	2.0		0.025	275/280
2002	Deere	MHD	CNG	8.1	2.5		0.06	250
2002	Ford	HDG	CNG	5.4	0.5		--	225
2002	GFI	HDG	CNG	6.8	1.5		--	245
2002	GFI	HDG	LPG	6.8	1.5		--	310
2002	PSA	HHD	Dual[e]	10.3	2.5		0.2	315/350
2002	PSA	HHD	Dual[e]	7.2	2.5		0.2	200/250
2002	PSA	HHD	Dual[e]	12.0	2.5		0.2	370/410
2001	AFT	MHD	CNG	7.6	1.5		--	250
2001	Baytech	HDG	Dual[d]	5.7	1.5		--	211/245
2001	Baytech	HDG	CNG	5.7	1.5		--	211
2001	Capstone	UB	Diesel	--	1.0		0.01	40
2001	Cummins	MHD	CNG	5.9	2.5		0.06	150/230
2001	Cummins	MHD	LPG	5.9	2.5		0.06	195
2001	Cummins	UB	CNG/LNG	8.3	2.5		0.025	275
2001	Cummins	MHD	CNG/LNG	8.3	2.5		0.06	250/275/280
2001	DDC	HHD	CNG/LNG	12.7	2.5		0.06	330/400
2001	DDC	UB	CNG/LNG	12.7	2.5		0.025	330/400
2001	DDC	UB	CNG/LNG	8.5	2.0		0.025	275
2001	Deere	MHD	CNG	6.8	2.5		0.06	225
2001	Deere	MHD	CNG	8.1	2.5		0.06	250
2001	Deere	UB	CNG	8.1	2.0		0.025	280
2001	Deere	HDG	CNG	8.1	2.0		--	280
2001	Ford	HDG	CNG	5.4	0.5		--	225
2001	IMPCO	HDG	LPG	8.1	1.5		--	276
2001	MACK	HHD	LNG	11.9	2.0		0.06	325
2001	PSA	MHD	Dual[e]	7.2	2.5		0.2	190/250
2001	PSA	HHD	Dual[e]	10.3	2.5		0.2	305
2001	PSA	HHD	Dual[e]	12.0	2.5		0.2	410
2001	Westport	HHD	Bi-Fuel[f]	14.9	2.5		0.2	410

[a] Service Type: MHD (Medium Heavy-Duty); HHD (Heavy Heavy-Duty); UB (Urban Bus)
[b] The optional NOx+NMHC emission standard is effective for most HDD engines manufactured on or after 10/1/2002
[c] PM emission levels are based on "In-Use" emissions data and presented in units of g/mile.
[d] Dual fuel (CNG or gasoline)
[e] Dual Fuel (CNG + Diesel; or LNG + Diesel)
[g] Power Systems Associates (using Caterpillar engine)
[d] Horsepower: 211 for CNG; 245 for gasoline

Figure 2.1. Sample EO.

Exhibit II-1
ARB Executive Order
for Heavy-Duty On-Road Engines

California Environmental Protection Agency AIR RESOURCES BOARD	CUMMINS INC.	EXECUTIVE ORDER A-021-0340 New On-Road Heavy-Duty Engines

Pursuant to the authority vested in the Air Resources Board (ARB) by Health and Safety Code (HSC) Division 26 Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by HSC Sections 39515 and 39516 and Executive Order (EO) G-02-003; and

Pursuant to the December 15, 1998 Settlement Agreement (SA) between ARB and the manufacturer, and any modifications thereof to the Settlement Agreement;

IT IS ORDERED AND RESOLVED: That the engine and emission control systems produced by the manufacturer are certified as described below for use in on-road motor vehicles with a manufacturer's GVWR over 14,000 pounds. Production engines shall be in all material respects the same as those for which certification is granted.

MODEL YEAR	ENGINE FAMILY	ENGINE SIZE (liter)	FUEL TYPE (CNG/LNG=compressed/liquefied natural gas; LPG=liquefied petroleum gas)	STANDARDS & TEST PROCEDURE	INTENDED SERVICE CLASS (L/M/H HDD=light/medium/heavy heavy-duty [HD] diesel; UB=urban bus; HDO=HD Otto)
2003	3CEXH0505CBK	8.3	CNG / LNG	Diesel	UB
SPECIAL FEATURES & EMISSION CONTROL SYSTEMS		ENGINE MODELS / CODES (rated power in horsepower, hp)			
TBI, OC, HO2S, TC, CAC, PCM		CG-280 / 8012 (280 hp), CG-275 / 8009 (275 hp), CG-250 / 8006 (250 hp), CG-250 / 8003 (250 hp)			

GVWR=gross vehicle weight rating TWC/OC=three-way/oxidizing catalyst WU (prefix) =warm-up cat. O2S=oxygen sensor HO2S=heated O2S TBI=throttle body fuel injection MFI=multi port fuel injection SFI=sequentialMFI DDI/IDI=direct /indirect diesel injection TC/SC=turbo/super charger CAC=charge air cooler EGR=exhaust gas recirculation AIR=secondary air injection PAIR=pulsed AIR SPL=smoke puff limiter ECM/PCM=engine /powertrain control module EM=engine modification 2 (prefix)=parallel (2) (suffix)=in series HC=hydrocarbon NMHC=non-methane HC NOx=oxides of nitrogen CO=carbon monoxide PM=particulate matter HCHO=formaldehyde g/bhp-hr=grams per brake horsepower-hour

The following are the exhaust emission standards (STD), or family emission limit(s) (FEL) as applicable, and certification levels (CERT) for this engine family under the "Federal Test Procedure" (FTP) (Title 13, California Code of Regulations, (13 CCR) Section 1956.1 (urban bus) or 1956.8 (other than urban bus)), and under the "Euro III Test Procedure" (EURO) in the Settlement Agreement, including EURO's "Not-to-Exceed" standard(s). "Diesel" CO certification compliance may have been demonstrated pursuant to Code of Federal Regulations, Title 40, Part 86, Subpart A, Section 86.091-23(c)(2)(i) in lieu of testing. (For flexible- and dual-fueled engines, the CERT values in brackets [ ] are those when tested on conventional test fuel. For multi-fueled engines, the STD and CERT values for default operation permitted in 13 CCR Section 1956.1 or 1956.8 are in parentheses.)

			EURO'S NOT-TO-EXCEED STD			NMHC: *		NOx: *		NMHC+NOx: 2.25			PM: 0.0375	
* = not applicable	HC		NMHC		NOx		NMHC+NOx		CO		PM		HCHO	
	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO
(DIRECT) STD	*	*	*	*	*	*	1.8	1.8	15.5	15.5	0.03	0.03	*	*
AVERAGE STD	*	*	*	*	*	*	*	*	*	*	*	*	*	*
FEL	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CERT	*	*	*	*	*	*	1.7	1.4	2.0	1.3	0.01	0.005	*	*

BE IT FURTHER RESOLVED: That certification to the FEL(s) listed above, as applicable, is subject to the following terms, limitations and conditions. The FEL(s) is the emission level declared by the manufacturer and serves in lieu of an emission standard for certification purposes in any averaging, banking, or trading (ABT) programs. It will be used for determining compliance of any engine in this family and compliance with such ABT programs.

BE IT FURTHER RESOLVED: That the listed engine models have been certified to the FTP optional NOx, or NMHC+NOx as applicable, and PM emission standard(s) listed above pursuant to 13 CCR Section 1956.1 or 1956.8.

BE IT FURTHER RESOLVED: That for the listed engine models, the manufacturer has submitted the materials to demonstrate certification compliance with 13 CCR Sections 1965 (emission control labels), and 2035 et seq. (emission control warranty).

BE IT FURTHER RESOLVED: That the listed engine models are conditionally certified subject to the following conditions: (1) The SA is in effect; (2) The manufacturer is in compliance with all applicable California emission regulations, and all SA's applicable requirements and any modifications thereof; (3) This EO is void with respect to any engine within this family determined to have a defeat device as that term is defined in the test procedures and SA. Any engine produced under the voided EO remains subject to stipulated penalties under the SA. Such penalties would begin to accrue upon manufacture of the first engine under this EO; (4) This EO expires at midnight on December 31, 2002; (5) Production of any engine within this family under this EO is acceptance of all conditions in this EO; and (6) ARB reserves the right to disapprove certification of this family, or any families using the same or similar auxiliary emission control device (AECD) strategies as this family is employing, based on all available information.

The Bureau of Automotive Repair will be notified by copy of this Executive Order.
Executed at El Monte, California on this 2ND day of October 2002.

Allen Lyons, Chief
Mobile Source Operations Division

The Settlement Agreements, as discussed earlier, require some heavy-duty engine manufacturers to produce heavy-duty engines meeting the 2004 emission standards of 2.4 or 2.5 g/bhp-hr NOx+NMHC starting October 1, 2002. Additionally, engine manufacturers subject to the October 2002 “pull-ahead” requirements are allowed the flexibility to pay non-conformance penalties in lieu of producing compliant engines. As a result of these provisions, engine manufacturers can currently sell engines that do not meet the 2.4 g/bhp-hr, or 2.5 g/bhp-hr, NOx+NMHC emission standard. Engines not certified to at least the 2.4 or 2.5 g/bhp-hr NOx+NMHC emission standards (i.e., NCP engines) are not eligible to participate in the CMP. This is to ensure that public funding is efficiently used to fund only the cleanest engine technology available.

Repowers

Vehicle repower refers to the replacement of an existing engine with a newer engine certified to lower emission standards. There may be limited opportunities to repower on-road vehicles with new engines. For example, the replacement of an old mechanical engine with a newer mechanical engine that is certified to a lower NOx emission standard may be cost effective. Mechanical engines are those having mechanically-controlled injection timing. These engines are common in pre-1991 models.

For the CMP, eligible HD diesel-to-diesel truck repower projects are those that replace uncontrolled mechanical engines with emission-controlled mechanical engines that meet the 15% minimum NOx reduction requirement. For mechanical-to-mechanical engine repowers, an applicant must provide the district with the vehicle identification number (VIN), engine model number, and serial number. ARB can then determine the project’s eligibility. Electronic-to-electronic engine repowers are allowed only when replacing a 1988 and later model year electronic engine with a diesel engine manufactured on or after October 1, 2002. If the replacement engine is not diesel-fueled, this October 2002 restriction does not apply. All other eligibility criteria must be met. Under the CMP, funding is not available for projects where spark-ignition engines (i.e., natural gas or gasoline, etc.) are replaced with new diesel engines.

Some air districts have expressed interest in mechanical-to-electronic engine repowers for on-road heavy-duty engines. Although substantial NOx emissions may occur by repowering a pre-1987 mechanical engine with an engine manufactured on or after October 1, 2002, installation of an electronically controlled engine into a mechanical engine platform is difficult due to significant fuel and electrical system differences. Thus, mechanical-to-electronic engine repower projects will be considered on a case-by-case basis. ARB and the local air district will evaluate the project and determine its merits.

Retrofits

Retrofit involves modifications to an engine and/or fuel system such that the retrofitted engine does not have the same specifications as the original engine. Retrofit projects are allowed for all engine model years, regardless of mechanical or electronic control. The most straightforward retrofit projects are those that could be done at the time of engine rebuild. Such a project may entail certain engine and/or fuel system component upgrade to result in a lower emission configuration. They may also include add-on aftertreatment. To qualify for funding, the engine retrofit kit must be verified to reduce NOx emissions by at least 15% compared to the original engine certification level. ARB has in place formal verification procedures for diesel emission control technology.

SAMPLE APPLICATION

A sample application form is included in the Appendix. The applicant must provide the minimum information illustrated in Table 2.4.

Table 2.4. Minimum Application Information On-road Projects.

1. Air District	9. Annual Diesel Gallons Used:
2. Applicant Demographics Company Name: Business Type: Mailing Address: Location Address: Contact Number:	10. Annual Miles Traveled: 11. Project Life (years): 12. Old Engine Information Horsepower Rating (for repowers and retrofits): Engine Make: Engine Model: Engine Year:
3. Project Description Project Name: Project Type: Vehicle Function: Vehicle Class: GVWR(lbs):	13. New Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year: Fuel Type:
4. NOx Reduction Incremental Cost Effectiveness Analysis Basis: (Mileage/Fuel/Hours of Operation)	
5. VIN or Serial Number:	14. Cost ($) of the Base Engine/Rebuild: (Labor and installation)
6. Application: (Repower, Retrofit or New)	15. Cost ($) of Certified Reduced-NOx Engine/Repower/Retrofit (Labor and Installation):
7. NOx Emissions Reductions Baseline NOx Emissions Factor: NOx Conversion Factors Used: Reduced NOx Emissions Factor: Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions:	16. District Incentive Amount Requested: 17. PM Emissions Reductions Baseline PM Emissions Factor: PM Conversion Factors Used: Reduced PM Emissions Factor: Estimated Annual PM Emissions Reductions: Estimated Lifetime PM Emissions Reductions:
8. Percent Operated in California:	

EMISSION REDUCTION AND COST-EFFECTIVENESS

Emission Reduction Calculation.

In general, the emission reduction benefit represents the difference in the emission level of a baseline vehicle/engine and a reduced-emission vehicle/engine. In situations where the model year of the vehicle chassis and the model year of the existing engine are different, the model year of the engine shall be used to determine the baseline emissions for benefit calculations. The emission level is calculated by multiplying an emission factor, an activity level, and a conversion factor, if necessary. Because conversion factors and the activity levels may be expressed in different units for the existing and replacement engines, it is recommended that emission levels for the baseline and reduced-emission vehicles/engines be calculated separately and then differences taken to determine emission reductions. For most on-road vehicles, the activity level is defined by the annual miles traveled as indicated by the vehicle odometer. However, refuse vehicles and street sweepers operating in predominantly stop and go applications are exceptions. In this case, the activity level shall be based on fuel use as indicated by actual annual fuel receipts or equivalent documentation. Emission reduction calculations shall be consistent with the type of records maintained over the life of the project.

The NOx emission factors have been updated to reflect the recently adopted EMFAC2002 emissions model, which accounts for excess NOx emissions from the settlement agreement engines. EMFAC2002 emission factors in units of grams/mile (g/mi) are based on chassis dynamometer test data. Appropriate NOx emission factors as a function of vehicle type and model year are illustrated in Tables 2.5, 2.6, and 2.7. These emissions are obtained during prescribed test procedures that involve collection of gaseous exhaust emissions in multiple sampling bags. The listed zero-mile emission factors for medium, heavy HDVs and urban buses correspond to bag two of the test procedure. For school bus project, emission factors must be determined according to GVWR. If fuel consumption is the basis for emission reduction calculations, a unit conversion factor is needed to translate g/mi to g/bhp-hr. The conversion factors listed in Table 2.8 should be used.

Table 2.5. Zero-mile NOx Emission Factors for Medium Heavy-Duty Vehicles 14,001 - 33,000 lbs GVWR.

Model Year	Grams per Mile
Pre – 1983	18.5
1984 – 1986	17.9
1987 – 1990	15.7
1991 – 1993	13.1
1994 – 1997	11.5
1998 – 2002	10.5
2003 +	5.8
2004 – 2006	5.5
2007+	0.5

Table 2.6 Zero-mile NOx Emission Factors for Heavy Heavy-Duty Vehicles 33,000 + lbs GVWR.

Model Year	Grams per Mile
Pre – 1975	28.5
1975 – 1983	27.2
1984 – 1986	20.2
1987 – 1990	16.8
1991 – 1993	16.0
1994 – 1997	19.1
1998	23.0
1999 – 2002	13.4
2003 – 2006	6.7
2007+	0.7

Table 2.7 Zero-mile NOx Emission Factors for Urban Buses.

Model Year	Grams per Mile
Pre – 1987	46.2
1987 – 1990	40.2
1991 – 1993	25.5
1994 – 1995	29.8
1996 – 1998	39.2
1999 – 2002	20.4
2003	10.2
2004 – 2006	2.5
2007+	1.0

Table 2.8 Diesel Equivalent Conversion Factors for Heavy-Duty Vehicle Projects (bhp-hr/mile).

Model Year	Medium Heavy-Duty Diesel 14,001-33,000 lbs.	Heavy Heavy-Duty Diesel 33,000 lbs. +	Urban Transit Bus [a] 33,000 lbs. +
Pre-1978	2.3	2.9	4.3
1978 - 1981	2.3	2.8	4.3
1982 - 1983	2.3	2.8	4.3
1984 - 1990	2.3	2.7	4.3
1991 - 1995	2.3	2.7	4.3
1996+	2.3	2.6 [b]	4.3

a. Urban transit buses over 33,000 gross vehicle weight rating (GVWR) or school buses over 33,000 GVWR in an urban area.
b. 2.6 bhp-hr/mile is for all heavy-duty line haul trucks (class 8).

The use of California's diesel fuel since 1993 (0.05 percent sulfur content by weight and 10 percent aromatic content by volume) would result in additional NOx and PM emissions from diesel engines compared to the base emission rates. Base emission rates for diesel engines, as embodied in EMFAC2002 and presented in Tables 2.5, 2.6, and 2.7 above, were derived from test data using either federal diesel fuel (0.05 percent sulfur content by weight) or pre-1993 diesel fuel. Thus, a fuel adjustment factor needs to be applied to the base emission rate to more accurately reflect the emissions from diesel engines when those engines are operated using California diesel fuel. Table 2.9 shows the fuel adjustment factors to be used for diesel engines.

Table 2.9 Fuel Correction Factors (On-Road Diesel Engines)

Model Year	NOx	PM
Pre – 1991	0.94	0.80
1991-1993	0.87	0.69
1994+	0.87	0.90

Refuse vehicles and street sweepers operating predominantly in stop-and-go applications accrue low mileage, yet intermittently operate at high load during compaction or sweeping mode. Therefore, a g/mi emission factor may not be appropriate for the vehicles. Furthermore, based on discussion with engine manufacturers, neighborhood refuse collection trucks are subject to limited off-cycle emissions. In an effort to improve the quantification of emissions, NOx emission factors for refuse vehicles and street sweepers operating predominantly in stop and go applications are listed in Table 2.10. An applicant may use the g/mi emission factors on a case-by-case basis, provided sufficient supporting documentation is submitted as determined by ARB.

Table 2.10. NOx and PM Emission Factors (g/bhp-hr) for Refuse Vehicles and Street Sweepers Predominantly in Stop-and-Go Applications.

Model Year	NOx	PM
Pre – 1987	10.0	0.60
1987 – 1990	6.0	0.60
1991 – 1998	5.2	0.10
1999 – 2002	4.4	0.10
2003 – 2006	2.5	0.10
2007+	0.2	0.01

If annual fuel consumption is the basis for the emission reduction calculations, an energy consumption factor (ECF) is used to convert g/bhp-hr to grams of emissions per gallon of fuel used (g/gal). HD diesel engines typically have a brake-specific energy consumption of 6,500 to 7,000 BTU/hp-hr on the certification cycle. Diesel fuel has an energy density of approximately 18,000 BTU/lb and a mass density of 7 lb/gal. This results in a specific ECF of

*(18,000 BTU/lb) * (7lb/gal) / ~6,800 BTU/hp-hr = 18.5 hp-hr/gal*

This factor may be used for refuse vehicles and street sweepers operating predominantly in stop-and-go applications. An engine specific ECF may be determined by: 1) dividing the horsepower rating of an engine by its fuel economy given in units of gal/hr or 2) dividing the energy density of the fuel (in units of BTU/gal) by the brake-specific fuel consumption of the engine.

The ECF is a number that combines the effects of engine efficiency and the energy content of the fuel used in that engine into an approximation of the amount of work output by an engine for each unit of fuel consumed. For alternative-fuel HD engines, the ECFs will vary depending on the engine efficiency and the energy density of the alternative fuel used in those engines. Since the efficiency of alternative fuel HD engines is approaching that of a diesel engine, their ECFs can be assumed to be of similar values to a diesel engine ECF on a diesel equivalent basis. Thus, for simplicity, ARB recommends that the ECF of 18.5 hp-hr/gal for diesel engines, as derived above, also be used for alternative fuel HD engines in conjunction with fuel consumption in terms of diesel gallons.

If an applicant proposes to use a different ECF that would be specific to an alternative fuel engine (e.g., liquefied natural gas engine (LNG)), the application must be supported by documentation to justify the proposed ECF. Typically, documentation is expected to include information on brake-specific energy consumption of the alternative fuel engine and energy density of the alternative fuel. For example, if LNG has an energy density of approximately 75,000 BTU/gal and an LNG engine is 95% efficient relative to a diesel engine with a brake-specific energy consumption of 6,800 BTU/hp-hr, the brake-specific energy consumption for the LNG engine is approximately 7,160 BTU/hp-hr (i.e., 6,800 BTU/hp-hr / 0.95). The ECF for this LNG engine is given as 75,000 BTU/gal / 7,160 BTU/hp-hr = 10.5 hp-hr/gal of LNG. This ECF would then be used to calculate emissions from the LNG engine.

While actual fuel receipts or other appropriate documentation support the annual fuel consumption of the baseline engine, the annual fuel consumption of the replacement reduced-emission engine may be estimated in proportion to the change in the ECF. For example, a replacement reduced-emission LNG engine having an ECF of 10.5 hp-hr/gal as discussed above, which replaces an existing diesel engine with a fuel use of 10,000 gal/yr and an ECF of 18.5 hp-hr/gal would have an estimated equivalent annual fuel consumption of 17,619 gallons/year or

*(10,000 gal/yr) * (18.5 hp-hr/gal) / (10.5 hp-hr/gal) = 17,619 gal/yr*

The outcome of both approaches can be compared. For an LNG engine certified to the 2.0 g/bhp-hr NOx emission standard and having an annual fuel consumption of 10,000 gal/yr of diesel fuel based on historical data for similar diesel engines, the emissions can be calculated in one of two ways, as follows:

1. Use of diesel ECF of 18.5 hp-hr/gal:
Annual emissions – (2.0g/bhp-hr)(18.5hp-hr/gal)*(10,000 gal/yr) = 370,000g/yr*

2. Use of LNG ECF of 10.5 hp-hr/LNG gal:
Estimated annual LNG consumption = 17,619 LNG gal/yr (see discussion above)
Annual emissions – (2.0 g/bhp-hr)(10.5 hp-hr/gal)*(17,619 LNG gal/yr) = 369,999 g/yr*

Refuse vehicles and street sweepers often have two engines, one for motive power and one for auxiliary operations. Emission benefits are calculated individually for each engine using fuel consumption rates for each unit if available. If the information is not available, the applicant must provide and document an estimate for the typical activities of each engine based on best engineering judgement so that emission can be determined. Factors such as fuel economy, typical operating loads, and hours of operation for each engine must be provided. Future fuel receipts or equivalent documentation should be submitted to the air district annually throughout the project or the 5-year life of the contract life for verification. The NOx emission reduction requirement continues to be 30% for new vehicle projects and 15% for retrofit and repower projects where emission reductions are determined based on engine emission factors.

Cost-Effectiveness Calculations

For eligible new heavy-duty vehicle purchases, only the incremental cost of the new vehicle equipped with an engine that meets the optional NOx emission credit standard compared to a conventional vehicle that meets the existing NOx emission standard will continue to be funded through the CMP. For vehicle repower projects, eligible cost for funding is the difference between the total installed cost of the newer, replacement engine and the total cost of rebuilding the existing engine. Funding requests for other related repowering equipment such as vehicle transmission will be considered on a case-by-case basis and is at the discretion of the district. For engine retrofit projects, the full cost of the retrofit kit may be funded subject to the $13,600 cost-effectiveness criterion.

For urban transit buses, only 20% of the total capital cost, which corresponds to the portion not funded by the Federal Transit Administration (FTA), are eligible for CMP funding, subject to the $13,600 C/E criterion. Full incremental cost for an urban transit bus may be granted under the CMP. However, this will continue to be considered on a case-by-case basis if the transit district demonstrates need satisfactorily. The transit district would need to provide ARB with its Transportation Implementation Plan (TIP) and annual updates. If data included in the TIP are not sufficient, ARB can require additional documentation. As in the past, operation and maintenance costs are not eligible for CMP funding.

Only funds provided by the CMP and local district matching fund are to be used in determining C/E. The one-time incentive grant amount is to be amortized over the expected project life (at least five years) considering an updated discount rate of 3%. The amortization formula (given below) yields a capital recovery factor (CRF), which, when multiplied by the initial capital cost, gives the annual cost of a project over its expected lifetime.

$$\text{CRF} = [(1 + i)^n (i)] / [(1 + i)^n - 1]$$

where

i = discount rate (3 %)

n = project life (at least 5 years)

Table 2.11 lists the CRF for different project lives using a discount rate of 3%. The previous discount rate of 5% was used in the initial CMP Guidelines, published in 1998. The discount rate is modified in the CMP guidelines to reflect the prevailing earning potential for state funds. The discount rate of 3% reflects the opportunity cost of public

Table 2.11. Capital Recovery Factors (CRF) for Various Project Life
At 3 Percent Discount Rate.

Project Life	CRF
5	0.218
6	0.185
7	0.161
8	0.142
9	0.128
10	0.117
11	0.108
12	0.100
13	0.094
14	0.089
15	0.084
16	0.080
17	0.076
18	0.073
19	0.070
20	0.067

funds allocated to the CMP. This is currently the level of earnings reasonably expected by investing state funds in various financial instruments over the length of the minimum life of CMP projects, such as 5-year U.S. Treasury Securities. Cost-effectiveness is determined by dividing the annualized costs of a project by the total annual NOx emission reductions offered by the project. Examples of various calculations for on-road vehicle projects are provided below.

Example 1
New CNG Vehicle Purchase (Calculations Based on Fuel Consumption)
A refuse collection company proposes to purchase a new CNG vehicle versus a diesel vehicle with a GVWR 58,000 lbs. The CNG engine was certified to the new NOx+NMHC emission credit standard of 1.8 g/bhp-hr. This vehicle is used for door-to-door refuse pick-up and operates 100% of the time in California.

Emission Reduction Calculation

Baseline NOx Emission factor (Table 2.10): 2.5 g/bhp-hr
Baseline NOx Emission Factor (using fuel correction factor in Table 2.9):
(2.5 g/bhp-hr)(0.87) = **2.18g/bhp-hr NOx**
Reduced NOx+NMHC Emission Factor: 1.8 g/bhp-hr
Reduced NOx Emission Factor (using default NOx fraction in Table 2.2):
(0.80)(1.8 g/bhp-hr) = **1.44g/bhp-hr NOx**
Conversion Factor: 18.5 bhp-hr/gal
Annual Fuel Consumption: 10,400 gal/year
% Operated in CA: 100 %
Convert grams to tons: ton/907,200 g

Hence, the estimated reductions are:
Baseline: (2.18 g/bhp-hr) * 18.5 bhp-hr/gal * 10,400 gal/year * 100% * ton/907,200 g = **0.46 ton/yr**

Reduced: (1.44 g/bhp-hr) * 18.5 bhp-hr/gal * 10,400 gal/year * 100% * ton/907,200 g = **0.30 ton/yr**
NOx emission reduction: 0.46 ton/yr – 0.30 ton/yr = 0.16 tons/year NOx emissions reduced

In this example, it is noted that the application of a single conversion factor, 18.5 bhp-hr/gal, for the energy content of diesel and CNG fuel is a first-order approximation. If the calculation relied on a CNG-specific conversion factor, annual fuel consumption of CNG, if known for the replacement engine, would be used to calculate emissions from the CNG engine. If the annual CNG consumption is not known, it can be estimated from the baseline diesel engine consumption using the ratio of energy consumption factors as described in the Emission Reductions and Cost-effectiveness section of this chapter.

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the CMP, any matching funds that were used to fund the project, the expected life of the project (10 years for most heavy-duty trucks), and the interest rate (3%) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Incremental Capital Cost:	\$ 135,000 (new CNG vehicle) - \$ 90,000 (new diesel vehicle) = \$ 45,000
Maximum Amount Funded:	\$ 45,000
Capital Recovery:	$[(1 + 0.03)^{10} (0.03)]/[(1 + 0.03)^{10} - 1] = 0.117$
Annualized Cost:	(0.117)(\$ 45,000) = \$ 5,265/year
Cost-Effectiveness:	(\$ 5,265/year)/(0.16 tons/year) **= \$ 32,906/ton**

The cost-effectiveness for the example is greater than the \$13,600 per ton cost-effectiveness requirement. In order to meet the \$13,600 per ton cost-effectiveness requirement, this project would only qualify for a fraction of the incremental cost to a maximum amount of approximately \$18,598. This amount is determined by multiplying the maximum allowed cost-effectiveness by the estimated annual emission reductions and dividing by the capital recovery factor (13,600*0.16/0.117).

Example 2
Urban Bus Purchase

A transit agency proposes to purchase a new (2003 model year) CNG bus instead of a new diesel bus. This new CNG bus is not included in the transit agency fleet average used to determine compliance with the ARB transit bus fleet rule or any other rule. The CNG engine was certified to the new NOx+NMHC emission credit standard of 1.8 g/bhp-hr. The costs of a CNG bus and a diesel bus are \$350,000 and \$310,000, respectively. The new bus will operate 100 percent of the time in California.

Emission Reduction Calculation

Baseline NOx Emission factor (Table 2.7): 10.2 g/mile
Adjusted Baseline NOx Emission Factor (using fuel correction factor in Table 2.9):
(10.2)(0.87) = 8.87 g/mile
Reduced NOx+NMHC Emission Factor: 1.8 g/bhp-hr
Reduced NOx Emission Factor (using default NOx fraction in Table 2.2):

	(0.80)(1.8 g/bhp-hr) = 1.44g/bhp-hr NOx
Conversion Factor:	4.3 bhp-hr/mile
Annual Miles:	50,000 miles
% Operated in CA:	100 %
Convert grams to tons:	ton/907,200 g

Hence, estimated annual NOx reductions are:
Baseline: (8.87 g/mile)* 50,000 miles/year * 100% * ton/907,200 g = 0.49 ton/yr
Reduced: (1.44 g/bhp-hr * 4.3 bhp-hr/mile)* 50,000 miles/year * 100% * ton/907,200 g = 0.34 ton/yr
NOx Emission Reduction: 0.49-034=0.15 tons/year NOx emissions reduced

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the CMP, any matching funds that were used to fund the project, the expected life of the project (12 years for urban bus), and the interest rate (3%) used to amortize the project cost over the project life. For urban bus purchases, FTA pays approximately 80% of the cost of a new transit bus. The incremental capital cost to the transit agency for this purchase and the maximum amount that could be funded through the CMP fund are determined as follows:

FTA Grant for purchase of new diesel bus:	(0.8)($ 310,000) = $ 248,000
Transit agency's cost for new diesel bus:	$ 310,000 - $ 248,000 = $ 62,000
FTA Grant for purchase of new CNG bus:	(0.8)($ 350,000) = $ 280,000
Transit agency's cost for new CNG bus:	$ 350,000 - $ 280,000 = $ 70,000
Incremental Capital Cost:	$ 70,000 - $ 62,000 = $ 8,000
Max. Amount Funded:	$ 8,000
Capital Recovery Factor:	$[(1 + 0.03)^{12} (0.03)]/[(1 + 0.03)^{12} - 1] = 0.100$
Annualized Cost:	(0.100)($ 8,000) = $ 800/year
Cost-Effectiveness:	($ 800/year)/(0.15 tons/year) **= $5,333/ton**

The cost-effectiveness for the example is less than $13,600 per ton of NOx reduced. This project would qualify for the maximum amount of grant funds requested - the incremental cost of what was not funded by FTA. A request for funding for the full incremental cost for a new urban transit bus would be considered on a case-by-case basis. The transit district must demonstrate need by providing ARB with its TIP and any annual updates. If data included in the TIP are not sufficient for ARB to determine need, additional information will be required. As with other categories, operating and maintenance costs are not funded by the CMP.

Example 3
Street Sweeper (Calculations Based on Fuel Consumption)

A city municipality proposes to buy a CNG street sweeper in 2003 instead of a diesel street sweeper. The main engine for the proposed street sweeper will be a CNG engine that is certified to the optional NOx+NMHC standard of 1.8 g/bhp-hr, while the auxiliary engine will be an off-road diesel engine certified to an optional NOx standard of 3.0 g/bhp-hr. This vehicle is operated entirely within city limits in California. Based on historical fuel usage, the main engine of the street sweeper uses approximately two-thirds of the total fuel consumed with the remaining one-third attributable to the auxiliary engine. The cost of a new CNG street sweeper is $162,000 compared to $122,000 for a new diesel powered street sweeper

Emission Reduction Calculation

Baseline NOx Emission factor (Table 2.10): 2.5 g/bhp-hr
Adjusted Baseline NOx Emission Factor (using fuel correction factor in Table 2.9):
(2.5)(0.87) = 2.18 g/mile
Reduced NOx+NMHC Emission Factor: 1.8 g/bhp-hr00
Reduced NOx Emission Factor (using default NOx fraction in Table 2.2):
(0.80)(1.8 g/bhp-hr) = **1.44g/bhp-hr NOx**

Conversion Factor:	18.5 bhp-hr/gal
Annual Fuel Consumption:	5,300 gal/year
% Operated in CA:	100 %
Convert grams to tons:	ton/907,200 g

Hence, the estimated reductions are:

Main Engine:

Baseline: (2.18 g/bhp-hr) * 18.5 bhp-hr/gal * 5,300 gal/year *(2/3)* 100% * ton/907,200 g = **0.16 ton/yr**
Reduced: (1.44 g/bhp-hr) * 18.5 bhp-hr/gal * 5,300 gal/year *(2/3)* 100% * ton/907,200 g = **0.10 ton/yr**
NOx Emission Reductions: 0.16-0.10 = 0.06 tons/year NOx emissions reduced

Auxiliary Engine:

Baseline NOx Emission factor: 6.9 g/bhp-hr
Adjusted Baseline NOx Emission Factor (using fuel correction factor in Table 3.6 since the auxiliary engine is an off-road engine): (6.9)(0.87) = 6.0 g/mile
Baseline Emissions:
6.0 g/bhp-hr* 18.5 bhp-hr/gal * 5,300 gal/year *(1/3)* 100% * ton/907,200 g = 0.22 ton/yr

Reduced NOx Emission factor: 3.0 g/bhp-hr
Adjusted Reduced NOx Emission Factor (using fuel correction factor in Table 3.6 since the auxiliary engine is an off-road engine): (3.0)(0.87) = 2.61 g/mile
Reduced Emissions:
(2.61 g/bhp-hr) * 18.5 bhp-hr/gal * 5,300 gal/year *(1/3)* 100% * ton/907,200 g = 0.09 ton/yr
NOx Emission Reduction: 0.22 - 0.09 = 0.13 ton/year NOx emissions reduced

Total Emission Reductions: 0.06 + 0.13 = 0.19 tons/year NOx emissions reduced

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the CMP, any matching funds that were used to fund the project, the expected life of the project (10 years for heavy-duty trucks), and the interest rate (3%) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the CMP are determined as follows:

Incremental Capital Cost:	\$ 162,000 - \$ 122,000 = \$ 40,000
Maximum Amount Funded:	\$ 40,000
Capital Recovery:	$[(1 + 0.03)^{10} (0.03)]/[(1 + 0.03)^{10} - 1] = 0.117$
Annualized Cost:	(0.117)(\$ 40,000) = \$ 4,680/year
Cost-Effectiveness:	(\$ 4,680/year)/(0.19 tons/year) **= \$ 24,632/ton**

The cost-effectiveness for the example is greater than the \$13,600 limit. In order to meet the \$13,600 per ton cost-effectiveness requirement, this project would only qualify for part of the incremental cost - a maximum amount of approximately \$22,085.

Example 4
Diesel to Diesel On-Road Repower (Calculations based on Mileage)
A line haul trucking company proposes to repower a 1983 heavy heavy-duty diesel line haul truck with a model year 1991 certified diesel engine. This vehicle operates 90% of the time in California.

Emission Reduction Calculation
Baseline NOx Emission factor (Table 2.6): 27.2 g/mile
Adjusted Baseline NOx Emission factor (using fuel correction factor in Table 2.9):
(27.2 g/mile)(0.94) = 25.57 g/mile

Replacement Engine (Reduced) NOx Emission factor (Table 2.6): 16.0 g/mile
Adjusted Replacement Engine NOx Emission factor (using fuel correction factor in Table 2.9):
(16.0 g/mile)(0.87) = 13.92 g/mile

Annual Miles:	60,000 miles
% Operated in CA:	90%
Convert grams to tons:	1 ton = 907,200 g

The estimated reductions are:
Baseline: (25.57 g/mile) * 60,000 mile/year * 90% * ton/907,200 g = 1.52 ton/yr
Reduced: (13.92 g/mile) * 60,000 mile/year * 90% * ton/907,200 g = 0.83 ton/yr

NOx Emission Reductions: 1.52-0.83=0.69 tons/year NOx emissions reduced

Cost and Cost-Effectiveness Calculations
The annualized cost is based on the portion of incremental project costs funded by the CMP, any matching funds that were used to fund the project, the expected life of the project (7 years default life for heavy-duty truck repowers), and the interest rate (3%) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the CMP fund are determined as follows:

Replacement Engine Cost	$30,000
Exist engine rebuild cost	$7,000
Incremental Capital Cost:	$ 30,000 - $ 7,000 = $ 23,000
Maximum Amount Funded:	$ 23,000
Capital Recovery (Table 2.10)	$[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 - 1] = 0.161$
Annualized Cost:	(0.161)($ 23,000) = $ 3,703/year
Cost-Effectiveness:	($ 3,703/year)/(0.69 tons/year) **= $ 5,367/ton**

The cost effectiveness for the example is less than $13,600 per ton of NOx reduced. This project qualifies for the maximum amount of grant funds requested.

Example 5
Diesel to Diesel On-Road Repower (Calculations based on Mileage)
A refuse company proposes to repower a 1970 heavy heavy-duty diesel transfer truck with a model year 1990 certified NOx diesel engine. This vehicle operates 100% of the time in California.

Emission Reduction Calculation

Baseline NOx Emission factor (Table 2.6): 28.5 g/mile
Adjusted Baseline NOx Emission factor (using fuel correction factor in Table 2.9):
(28.5 g/mile)(0.94) = 26.79 g/mile

Reduced NOx Emission factor (Table 2.6): 16.8 g/mile
Adjusted Reduced NOx Emission factor (using fuel correction factor in Table 2.9):
(16.8 g/mile)(0.94) = 15.79 g/mile

Annual Miles:	120,000 miles
% Operated in CA:	100%
Convert grams to tons:	ton/907,200g

Hence, the estimated reductions are:
Baseline: (26.79 g/mile) * 120,000 mile/year * 100% * ton/907,200 g = 3.54 ton/yr
Reduced: (15.79 g/mile) * 120,000 mile/year * 100% * ton/907,200 g = 2.09 ton/yr
NOx Emission Reductions: 3.54-2.09=1.45 tons/year NOx emissions reduced

Cost and Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the CMP, any matching funds that were used to fund the project, the expected life of the project (7 years default life for heavy-duty truck repowers), and the interest rate (3%) used to amortize the project cost over the project life. The incremental capital cost to the fleet operator for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Incremental Capital Cost:	\$ 25,000 (replacement engine) - \$ 4,000 (for rebuild) = \$ 21,000
Maximum Amount Funded:	\$ 21,000
Capital Recovery:	$[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 - 1] = 0.161$
Annualized Cost:	(0.161)(\$ 21,000) = \$ 3,381/year
Cost-Effectiveness:	(\$ 3,381/year)/(1.45 tons/year) **= \$ 2,332/ton**

The cost-effectiveness for the example is less than \$13,600 per ton of NOx reduced. This project qualifies for the maximum amount of grant funds requested.

The following example shows two different ways to calculate emission benefits for projects involving alternative-fuel engines. First, by using different energy consumption factors for diesel and LNG engines and their corresponding annual fuel consumption. Second, by using the same default ECF and diesel fuel baseline usage.

Example 6

New LNG Line-Haul Truck Purchase (Calculations Based on Fuel Consumption)

A trucking company proposes to purchase a new LNG line-haul truck versus a diesel line-haul truck. The LNG engine was certified to the new NOx+NMHC emission credit standard of 1.8 g/bhp-hr. The fleet operator currently operates some LNG trucks and has specific information on the annual amount of LNG used per truck. The fleet operator wants to use an ECF of 10.5 bhp-hr/LNG gal for the LNG engine (see discussion in the Emission Reductions and Cost-Effectiveness section of this chapter). This vehicle is used to transport goods throughout the state and operates 100 percent of the time in California.

Emission Reduction Calculation

Baseline NOx+NMHC Emission factor: 2.5 g/bhp-hr
Adjusted Baseline NOx Emission Factor (using default NOx fraction in Table 2.2 and fuel correction factor in Table 2.9): (2.5 g/bhp-hr)(0.95)(0.87) = **2.07g/bhp-hr NOx**
Reduced NOx+NMHC Emission Factor: 1.8 g/bhp-hr
Adjusted Reduced NOx Emission Factor (using default NOx fraction in Table 2.2): (1.8 g/bhp-hr)(0.80) = **1.44g/bhp-hr NOx**
Conversion Factor (new diesel engine): 18.5 bhp-hr/gal
Conversion Factor (new LNG engine): 10.5 bhp-hr/LNG gal
Annual LNG Fuel Consumption: 35,000 gal/year
Estimated diesel consumption (estimated from ratio of ECFs, described in Emission Reductions and Cost-Effectiveness section of this chapter)**:** (35,000 LNG gal)(10.5/18.5) = 19,865 diesel gallons/year
% Operated in CA: 100 %
Convert grams to tons: ton/907,200 g

Hence, the estimated reductions are:
Baseline emissions: 2.07 g/bhp-hr * 18.5 bhp-hr/gal * 19,865 gal/year * 100% * ton/907,200 g = **0.84 t/y**
Reduced emissions: 1.44 g/bhp-hr * 10.5 bhp-hr/gal * 35,000 gal/year * 100% * ton/907,200 g = **0.58 t/y**
NOx Emission Reductions: 0.84 – 0.58 t/y = 0.26 t/y

This example illustrates the application of separate conversion factors, 10.5 bhp-hr/gal for LNG engine and 18.5 bhp-hr/gal for diesel engine. If the calculation relied on a single default conversion factor of 18.5 bhp-hr/gal and using the default annual diesel fuel consumption for both engines, the same result is obtained as shown below.

Annual Diesel Fuel Consumption: 19,865 gal/year
Default Conversion Factor: 18.5 bhp-hr/gal

The estimated reductions are:
Baseline emissions: 2.07 g/bhp-hr * 18.5 bhp-hr/gal * 19,865 gal/year * 100% * ton/907,200 g = **0.84 t/y**
Reduced emissions: 1.44 g/bhp-hr * 18.5 bhp-hr/gal * 19,865 gal/year * 100% * ton/907,200 g = **0.58 t/y**
NOx Emission Reductions: 0.84 – 0.58 t/y = 0.26 t/y

Reporting and Monitoring

The district will continue to have the authority, and is encouraged, to conduct periodic checks or solicit operating records from the grantee of CMP funds for new heavy-duty vehicle purchase, vehicle repowering, or engine retrofit projects. Monitoring of project progress ensures that the vehicle or engine is operated as stated in the program application. Fleet operators and transit agencies participating in the CMP are required to keep appropriate records during the life of the funded project. Records must contain, at a minimum, total miles traveled in and outside of California, fuel usage, and maintenance and repair information. Records must be retained and updated throughout the project life and made available at the request of the district or ARB.

Chapter Three
OFF-ROAD EQUIPMENT

This chapter presents the project criteria for off-road equipment projects under the CMP. It also contains a brief overview of the current emission standards, available control technology, potential incentive projects eligible for funding, and emission reduction and cost-effectiveness calculation methodologies.

EMISSION STANDARDS

Off-road engines are used in a wide array of applications including agricultural tractors, backhoes, excavators, trenchers, and motor graders. Off-road equipment can be further categorized broadly into: equipment less than 175 hp and equipment equal to or greater than 175 hp. The ARB is preempted from regulating new farm and construction equipment less than 175 hp. The U.S.EPA has sole authority to regulate this type of equipment. ARB has the authority to regulate new off-road equipment equal to or greater than 175 hp and non-preempted off-road equipment less than 175 hp.

Off-road equipment eligible for CMP funding includes equipment 50 hp or greater. Excluded from this discussion are engines that propel or are used on aircraft, locomotives, marine vessels, forklifts, and ground support equipment (GSE). Engines used in locomotive, marine vessel applications, forklifts, and GSE's are discussed elsewhere in this document. Aircraft engines are excluded from the CMP. In addition, the CMP does not apply to off-road engines used for underground mining operations, which are regulated by the Mining Safety and Health Administration (MSHA).

Emissions from off-road equipment were uncontrolled prior to 1996. Estimates of NOx emission levels from uncontrolled off-road engines range from 8.2 g/bhp-hr to 14 g/bhp-hr. In January 1992, ARB adopted exhaust emission standards for off-road diesel-cycle engines 175 hp and greater to be effective starting with the 1996 model year engines.

The U.S.EPA, ARB, and off-road diesel engine manufacturers have signed a Statement of Principles (SOP) that sets forth comprehensive future emission standards for compression ignition (diesel) off-road engines. The SOP provides for new NOx+NMHC, PM, and carbon monoxide (CO) emission standards for engines with different horsepower ratings to be effective in a tiered approach. The SOP's Tier 1 NOx emission levels for off-road diesel engines 50 hp and greater are the same as the ARB's NOx emission standards for off-road diesel cycle engines 175 hp or greater. Starting with model year 2001 engines, the SOP provides for a combined NOx+NMHC emission levels (Tier 2) for off-road engines in this category ranging from 4.8 g/bhp-hr to 5.6 g/bhp-hr. The Tier 2 NOx+NMHC emission levels for off-road diesel engines 50 hp and greater will be reduced further with the incorporation of the Tier 3 emission levels, ranging from 3.0 g/bhp-hr to 3.5 g/bhp-hr NOx + NMHC, starting in 2005. The U.S.EPA has adopted regulations for off-road diesel equipment consistent with the emission levels contained in the SOP. The ARB has revised California's regulations for off-road equipment to harmonize with federal regulations. As such, the emission standards for off-road CI engines are now the same for federal and California engines. Table 3.1 summarizes the existing and future emission standards for these engines.

As illustrated in Table 3.1 and similar to on-road HD engines discussed in the previous chapter, the emission standards for HD diesel off-road engines have also changed in 2002 from a NOx standard to a combined NOx+NMHC standard. In the CMP, eligibility is based on the C/E of NOx reductions. To determine the NOx fraction from the combined NOx+NMHC values, the same approach discussed for on-road HD engines is suggested for off-road engines. Briefly, certification data submitted to ARB for both diesel and natural gas (NG) engines suggest that, on average, the NOx fraction in the NOx+NMHC certified emission values from diesel engines range from 90% to 98%. For NG-fueled engines, the NOx fraction is approximately 80% of the combined NOx+NMHC certified emission values. This information is the basis for the guidance proposed in Table 3.2. Thus, to determine NOx emissions, the certification NOx+NMHC emission standard for an engine is multiplied by the appropriate NOx fraction. A different NOx fraction than the default values illustrated in Table 3.2 may be used if justified by proper documentation submitted to ARB for consideration.

The CMP will continue to provide near-term, surplus emission reductions by encouraging the purchase of eligible new off-road equipment or certified off-road engines to replace eligible uncontrolled engines. This program also supports repower projects of emission-certified equipment with engines certified to lower optional NOx emission credit standard. All eligible projects must use certified technology or technology that has been evaluated and verified by the ARB for real and quantifiable emission reductions that go beyond any regulatory requirement.

Current off-road engine regulations contain provisions that assist engine manufacturers in complying with emission standards through: 1) averaging, trading, and banking (AB&T) programs and 2) flexibility provisions for non-compliant engines. The objective of the CMP continues to be the deployment of cleaner-than-required low-emission engines to achieve maximum emission reduction benefits. Thus, engines produced under these provisions are not eligible for the CMP. Off-road engine manufacturers are legally allowed the flexibility to participate in an AB&T program in lieu of only producing engines that are compliant with the current emission standards. The emission benefits from an engine certified to a lower Family Emission Limit (FEL) are necessary to offset the emissions from engines certified to a higher FEL levels within the engine manufacturer’s AB&T program. Thus, the possible emission benefits from and FEL engine are not surplus emissions. In addition, current regulations for off-road heavy-duty CI engines contain flexibility provisions that allow engine manufacturers to produce a certain number of non-compliant engines. Thus, flexibility engines are not certified to current emission standards.

Table 3.1. Off-Road Compression-Ignition Engine Standards.
NMHC+NOx/CO/PM in g/hp-hr (g/kW-hr)
Standards Include an Emissions Durability Period[c,d,e]

hp (kw)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
<11 (8)[c]					7.8 (10.5) 6.0 (8.0) 0.75 (1.0)					5.6 (7.5) 6.0 (8.0) 0.60 (0.80)			
11 (8) <25 (19)[c]					7.1 (9.5) 4.9 (6.6) 0.60 (0.80)					5.6 (7.5) 4.9 (6.6) 0.60 (0.80)			
25 (19) <50 (37) [c,d]				7.1 (9.5) 4.9 (6.6) 0.60 (0.80)					5.6 (7.5) 4.1 (5.5) 0.45 (0.60)				
50 (37) <100 (75)[e]			N/A[a] 6.9 (9.2) N/A N/A						5.6 (7.5) 3.7 (5.0) 0.30 (0.40)				3.5 (4.7) 3.7 (5.0) (b)
100 (75) <175 (130) [e]		N/A[a] 6.9 (9.2) N/A N/A						4.9 (6.6) 3.7 (5.0) 0.22 (0.30)				3.0 (4.0) 2.6 (3.5) (b)	
175 (130) <300 (225) [e]	1.0 (1.3) [a] 6.9 (9.2) 8.5 (11.4) 0.40 (0.54)							4.9 (6.6) 2.6 (3.5) 0.15 (0.20)			3.0 (4.0) 2.6 (3.5) (b)		
300 (225) <600 (450) [e]	1.0 (1.3) [a] 6.9 (9.2) 8.5 (11.4) 0.40 (0.54)					4.8 (6.4) 2.6 (3.5) 0.15 (0.20)				3.0 (4.0) 2.6 (3.5) (b)			
600 (450) <750 (560) [e]	1.0 (1.3)[a] 6.9 (9.2) 8.5 (11.4) 0.40 (0.54)						4.8 (6.4) 2.6 (3.5) 0.15 (0.20)			3.0 (4.0) 2.6 (3.5) (b)			
>750 (560) [e]					1.0 (1.3)[a] 6.9 (9.2) 8.5 (11.4) 0.40 (0.54)						4.8 (6.4) 2.6 (3.5) 0.15 (0.20)		

(a) Standards given are HC/NOx/CO/PM in g/hp-hr (g/kW-hr).
(b) PM standards have not been specified.
(c) For all engines rated under 25 hp (19 kW), and for constant speed engines rated under 50 hp (37 kW) with rated speeds greater than or equal to 3,000 rpm, the durability period and useful life is a period of 3,000 hours or five years of use, whichever first occurs.
(d) For all other engines rated at or above 25 hp (19 kW) and under 50 hp (37 kW), the durability period and useful life is a period of 5,000 hours or seven years of use, whichever first occurs.
(e) For all engines rated at or above 50 hp (37 kW), the durability period and useful life is a period of 8,000 hours of operation or ten years of use, whichever first occurs.

Table 3.2 NOx Fraction Default Values.

Diesel Engines	Alternative Fuel Engines
0.95	0.80

In terms of retrofit applications, two options are eligible for CMP funding. Grants can be used for the purchase of eligible retrofit kits that reduce NOx emissions from the levels emitted by an uncontrolled engine to the Tier 1 or 6.9 g/bhp-hr NOx emission standard or lower. In addition, an eligible retrofit kit for an emission-certified engine must result in a minimum NOx emission reduction of 15% percent.

CONTROL TECHNOLOGIES

The purpose of this section is to discuss reduced-emission engines for off-road equipment that are commercially available. The engines discussed are considered suitable as new equipment purchase or new engine purchase for repower opportunities. Emerging technologies that may be commercially available in the near future are also discussed.

Emission-Certified Engines

Off-road diesel-fueled engines 50 hp and greater must comply with either a NOx and HC Tier 1 emission standards or a combined NOx+NMHC Tier 2 emission standard (see Table 3.1). Currently, all new off-road diesel engines ranging from 300 hp to less than 750 hp are required to comply with the Tier 2 NOx+NMHC emission standard of 4.8 g/bhp-hr. Similarly, off-road diesel engines ranging from 100 hp to less than 300 hp have to meet a Tier 2 NOx+NMHC emission standard of 4.9 g/bhp-hr. Tier 2 emission standards of 5.6 g/bhp-hr NOx+NMHC will be required in 2004 for diesel engines ranging from 50 hp to less than 100 hp. In 2006, the Tier 2 requirements of 4.8 g/bhp-hr extend to engines in the range of 750 hp and greater. As discussed previously, these standards do not apply to engines used in aircraft, locomotive, or marine vessel applications.

One viable and cost-effective strategy to reduce emissions from older, uncontrolled equipment is the replacement of the in-use engine (i.e., repower) with an emission-certified engine instead of rebuilding the existing engine to its original uncontrolled specifications. Although this is commonly a diesel-to-diesel repower, significant NOx and PM benefits may be achievable due to the high emission levels of the uncontrolled engine being replaced. Off-road equipment comes in a variety of sizes, weights, and power ratings. Emission-certified engines are commercially available for off-road engines 50 hp and greater that are eligible for CMP funding. Other possible options include the replacement of an older uncontrolled diesel off-road engine with a new or rebuilt on-road engine certified to, at least, a NOx emission standard of 6.0 g/bhp-hr or a newer emission-certified alternative fuel engine. However, although they may be eligible for CMP funding, it is recognized that diesel-to-alternative fuel repower projects for off-road equipment are not expected to be as common as diesel-to-diesel repowers.

Off-Road Engine Retrofit Technology.
Any retrofit technology must be verified for sale in California, must be able to reduce NOx emissions by at least 15% in the case of an existing emission-certified engine, and must comply with established durability and warranty requirements. However, retrofit technology options for off-road diesel engines, which reduce NOx emissions from uncontrolled-engine levels to, at least, the Tier 1 6.9 g/bhp-hr NOx emission standard are limited. It is possible that retrofit technologies that have been used to reduce NOx and PM emissions from on-road heavy-duty diesel engines may be used to control off-road engine emissions in some applications.

Emerging Technologies
Several reduced-emission technologies hold promise for the future, but are not yet commercially available. These technologies, as discussed in the previous chapter, are being developed for both on-road and off-road heavy-duty diesel engines. Some of these technologies may include NOx catalyst and selective catalytic reduction. These technologies may be developed as engine retrofit or new engine technologies and become eligible for program participation after ARB grants verification for sale in California. In addition, the criteria for evaluation of other promising emerging technologies for off-road engine applications is the same as the criteria discussed for on-road engines. Briefly, in the event that a unique technology with demonstrated potential for emission reductions has been evaluated by ARB, an experimental permit may allow the engine technology to operate in California. In some cases, ARB's Executive Office may grant approval for participation in the CMP. These applications are considered on a case-by-case basis and are typically granted with strict limitations for demonstrations only.

PROJECT CRITERIA
Project eligibility criteria have been designed to provide the reader with a list of minimum qualifications required for a CMP off-road equipment project. Emission reductions, cost effectiveness, and the ability for completion of the funded project during the timeframe of the program continue to be the primary criteria for eligibility. Reduced-NOx off-road equipment projects that include equipment repowers or engine retrofits will be considered and evaluated for incentive funding. In general, off-road equipment projects must meet the following criteria:

- For new equipment purchase, the new engine must be certified to an ARB optional NOx or NOx+NMHC emission credit standard for off-road diesel equipment that is at least 30% lower than the current applicable emission standard.

- For equipment repower projects that replace uncontrolled engines in existing equipment, a new replacement engine must be certified to the current emission standard or to an optional credit emission standard as applicable for the horsepower rating.

- In the event that the use of a new replacement engine meeting the current applicable standard is not technically feasible, the replacement unit must be a new replacement engine or an emission-certified rebuilt or remanufactured engine meeting the previously applicable emission standard. At present, in most cases the previously applicable standard is Tier 1. The determination of eligibility of a newer engine for repower shall be made on case-by-case basis by ARB and district staff.

- For equipment repower projects that replace emission-certified engines in existing equipment, the new or newer replacement engine must be certified to a NOx emission standard that is at least 15% lower than the emission standards applicable to the existing engine.

- Newer replacement engines used in equipment repower projects could be either new, rebuilt, or remanufactured units. Eligible rebuilt or remanufactured engines must be emission-certified, use only OEM components, and be procured from the OEM or its authorized dealers/distributors.

- If the replacement engine is rated an a higher horsepower than the existing engine, the load factor for the replacement engine must be corrected for the power rating difference,

  $$\textit{Load Factor}_{replacement} = \textit{Load Factor}_{existing} * hp_{existing}/hp_{replacement}$$

  This criterion would also apply to other project categories using off-road engines (i.e., agricultural pumps, forklifts, etc.)

- For engine retrofit projects: (i) the retrofit kit must be verified to reduce NOx emissions to 6.9 g/bhp-hr, or lower, when used to retrofit an eligible uncontrolled engine, or (ii) the retrofit kit must be verified to reduce NOx emissions by at least 15% when used to retrofit eligible emission-certified engines.

- Reduced-emission engines or retrofit kits must be verified for sale in California and must comply with durability and warranty requirements. Qualified engines could include new ARB-certified engines or ARB-certified aftermarket part engine/control devices.

- Engines designated for participation in any averaging, banking, and trading (AB&T) program are ineligible to participate in the Carl Moyer Program.

- Engines manufactured under the flexibility provisions for off-road compression-ignition (diesel) engines that do not meet the current required standards are ineligible to participate in the Carl Moyer Program.

- If applicable, NOx emission levels shall be determined by multiplying 0.95 to the certified NOx+NMHC emission standard for diesel engines and by 0.80 for alternative fuel engines.

- For diesel engines only, multiply the base NOx emission rate by the appropriate fuel correction factor shown in Table 3.6, in addition to other calculation adjustments.

- NOx reductions obtained through this program must not be required by any existing regulations, memoranda of understanding/agreement, or other legally binding documents.

- Funded projects must operate for a minimum of 5 years and at least 75% of total equipment hours of operation must occur in California.

- The acceptable maximum project life for calculating benefits from off-road projects is as follows:

	Default without Documentation	Default with Documentation
Off-road New	10 years	15 years
Off-road Repower	7 years	15 years

  Project life beyond the "default without documentation" limits may be submitted for approval by ARB.

- Projects must meet a cost-effectiveness criterion of $13,600 per ton of NOx reduced.

- Off-road projects that fall outside of these criteria may be considered on a case-by-case basis if evidence provided to the air district suggests potential, surplus, real, quantifiable, and enforceable emission reduction benefits.

TYPES OF POTENTIAL PROJECTS

The eligibility requirements for off-road engine projects are illustrated in the checksheet of Table 3.3. A goal of the CMP is to achieve emission reductions from off-road diesel engines/equipment operating in California as early and as cost-effectively as possible. The revised project criteria included in this chapter are designed to ensure that emission reductions achieved by the deployment of reduced-emission engines or retrofit technologies continue to be surplus, real, quantifiable, and enforceable. A project must meet a C/E criterion of $13,600 per ton of NOx reduced. In addition, participating districts have the option of setting funding caps based on the engine horsepower ratings, not to exceed the C/E threshold of $13,600. All funded projects must operate for at least five years. 75% of the total hours of operation must occur in California.

<u>Purchase of New Equipment Powered by New Emission-Certified Engines</u>

For most engine categories, the current standard is Tier 2 with an optional standard starting at 4.0 g/bhp-hr NOx+NMHC and decreasing in 0.5 g/bhp-hr decrements. However, it is recognized that at this time, off-road engines certified to an optional NOx emission credit standard are not available.

For some off-road equipment such as yard hostlers, it may be possible to repower with a new on-road engine certified to an optional NOx emission credit standard instead of a new off-road engine. Where this is the case, emission benefits relative to the baseline engine would be calculated based on an on-road engine. If an applicant provides ARB

Table 3.3. Off-road Engine Project CMP Eligibility Checksheet.

New Equipment Purchase	Engine in new equipment must be certified to optional emission standard that is at least 30% lower than current standard for engine

Equipment Repower

Existing Engine	New Replacement Engine	OEM Rebuilt/Remanufactured Replacement Engine
<u>Uncontrolled</u>	1. Must be certified to current emission standard 2. On a case-by-case basis, and with approval, may consider new replacement engine certified to a previously applicable emission standard if use of an engine meeting the current emission standard is not technically feasible 2. Must achieve at least 15% NOx emission reductions from baseline emissions of existing engine	1. Must be emission-certified 2. Must achieve at least 15% NOx emission reductions from baseline emissions of existing engine
Emission-Certified	1. Must be certified to current emission standard 2. Must achieve at least 15% NOx emission reduction from baseline emission of existing engine	1. Must be emission-certified 2. Must achieve at least 15% NOx emission reductions from baseline emissions of existing engine

Engine Retrofit

Existing Engine	New Retrofit Kit
<u>Uncontrolled</u>	Retrofit kit has to be verified to reduce emissions to at least Tier 1 (6.9 g/bhp-hr)
<u>Emission-Certified</u>	Retrofit kit has to be verified to reduce emissions by at least 15% relative to baseline emissions of existing engine

with documentation showing that in past practices, the current fleet has been powered by off-road engines, then an off-road engine emission factor baseline is applicable.

Repower with Emission-Certified Engines

Purchases of new emission-certified engines to replace uncontrolled engines in existing equipment are the most common type of project for off-road diesel repowers under the CMP. In the event that repowering with a new engine meeting current applicable emission standards (Tier 2) is not technically feasible as determined by ARB and district staff, a newer emission-certified engine that meets the previously applicable standards (Tier 1) may be used upon ARB approval. HD off-road CI engines have undergone major design changes to meet new and stringer emission regulations. Off-road engine manufacturers have made significant hardware modifications in order to meet the current Tier 2 emission standards for engines with horsepower rating of 100 hp and greater. The incorporation of air-to-air cooling and other auxiliary systems have resulted in Tier 2 engines for some applications that are physically and technically different than the earlier Tier 1 engines. As a result, a number of existing equipment cannot accept Tier 2 engines without extensive modifications. In some cases, this may involve cutting the equipment frame to gain adequate space for the Tier 2 engine. In these situations, technical, cost, and safety considerations make a new Tier 2 engine repower infeasible. Thus, the use of a newer emission-certified engine meeting the earlier Tier 1 emission standard may be justified. ARB and air district staff will consider repower project applications that call for the use of newer engines not meeting current emission standards on a case-by-case basis.

Eligible off-road equipment repower projects also include the replacement of an emission-certified engine with a newer and similarly certified engine that meets an optional NOx emission credit standard. Furthermore, another possible option may be to repower off-road diesel equipment with a new or rebuilt on-road engine certified to a NOx emission standard of at least 6.0 g/bhp-hr. ARB, on a case-by-case basis, may grant an experimental permit for operation of the off-road equipment with the on-road engine. Consideration for funding under the CMP would be given on a case-by-case basis. CMP funding is not available for projects where a spark-ignition engine (i.e., natural gas, gasoline, etc.) is replaced with a diesel engine.

Off-road equipment repower projects that replace an existing diesel engine with an eligible reduced-emission diesel engine (either off-road or on-road) are not subject to statewide funding caps under the revised guideline criteria. However, local districts have the authority to impose stringer criteria including funding caps in order to maximize the local air quality benefits. Finally, off-road engine emission factors have been updated and are in agreement with the most recent version of the OFFROAD inventory model.

Retrofits

Retrofit refers to modifications made to an engine and/or fuel system such that the specifications of the retrofitted engine are not the same as the original engine. Retrofit projects may be applicable to an entire diesel engine family. The most straightforward retrofit projects are upgrades of components that can be accomplished at the time of engine rebuild and result in a lower emission configuration. It is possible that retrofit technologies that have been used to reduce NOx and PM emissions from on-road heavy-duty diesel engines could be used to control off-road engine emissions in some applications. To qualify for CMP funding, the retrofit kit for an uncontrolled engine must be certified to reduce NOx emissions to 6.9 g/bhp-hr or lower. The CMP may also be used to fund retrofit kits for emission-certified engines that result in NOx emission reductions of at least 15%.

SAMPLE APPLICATION

Districts solicit bids for reduced-emission projects from off-road diesel equipment operators and make applications available upon request. A sample application form is included in the appendices. The applicant must provide the minimum information illustrated in Table 3.3. Air district can request additional information.

Table 3.3. Minimum Application Information Off-road Projects.

Air District	Annual Diesel Gallons Used
Applicant Demographics Company Name Business Type Mailing Address Location Address Contact Number	Annual Miles Traveled Hours of Operation Project Life (years)
Project Description Project Name Project Type Equipment Function	Existing Engine Information Horsepower Rating Engine Make Engine Model Engine Year
NOx Reduction Incremental Cost Effectiveness Analysis Basis: (Mileage/Fuel/Annual Hours) VIN or Serial Number Application: (Repower, Retrofit or New)	Replacement Engine Information Horsepower Rating Engine Make Engine Model Engine Year Fuel Type
NOx Emissions Reductions Baseline NOx Emissions Factor (g/bhp-hr) NOx Conversion Factors Reduced NOx Emissions Factor (g/bhp-hr) Estimated Annual NOx Emissions Reductions Estimated Lifetime NOx Emissions Reductions	Cost ($) of the Existing Engine: Cost ($) of Certified LEV Replacement Engine District Incentive Amount Requested
Percent Operated in California	PM Emissions Reductions Baseline PM Emissions Factor PM Conversion Factors Used: Reduced PM Emissions Factor: Estimated Annual PM Emissions Reductions Estimated Lifetime PM Emissions Reductions

EMISSION REDUCTION AND COST-EFFECTIVENESS

Emission Reduction Calculation

Emission reduction benefits represent the difference in the emission levels of the existing baseline engine relative to the newer, reduced-emission, replacement engine. Baseline emission factors are listed in Table 3.4. These reflect the recently adopted OFFROAD emission inventory model for off-road large CI engines greater than or equal to 25 hp. OFFROAD incorporates recent data and reflects currently adopted regulations. For CMP applicants wishing for an alternative to the baseline emission factors illustrated in Table 3.4, dynamometer testing of an uncontrolled engine using ARB-approved test procedures may be employed to determine actual emission factors. The maximum allowable baseline emissions for pre-1996 engines as determined through in-use testing is 13 g/bhp-hr (<120 hp) and 14 g/bhp-hr (>120 hp).

Table 3.4. Baseline NOx and PM Emission Factors for Uncontrolled Off-Road HD Diesel Engines (g/bhp-hr).

Horsepower	Engine Model Year	NOX (g/bhp-hr)	PM (g/bhp-hr)
50-120	Pre-1988	13	0.84
50-120	1988-1997	8.75	0.69
121-175	Pre-1970	14	0.77
	1970-1971	13	0.66
	1972-1979	12	0.55
	1980-1987	11	0.55
	1988-1996	8.17	0.38
176-250	Pre-1970	14	0.77
	1970-1971	13	0.66
	1972-1979	12	0.55
	1980-1987	11	0.55
	1988-1995	8.17	0.38
251-750	Pre-1970	14	0.74
	1970-1971	13	0.63
	1972-1979	12	0.53
	1980-1987	11	0.53
	1988-1995	8.17	0.38
>750	Pre-1970	14	0.74
	1970-1971	13	0.63
	1972-1979	12	0.53
	1980-1987	11	0.53
	1988-1999	8.17	0.38

In situations where the model year of the equipment and the model year of the existing engine are different, the model year of the engine will be used to determine the baseline emission factor for emission reduction calculations. For off-road equipment (i.e., yard hostlers, yard goats) capable of operation with a new certified on-road engine meeting an optional NOx emission credit standard instead of a new off-road engine, emission benefits from the baseline engine will be based on an on-road engine. If an applicant provides sufficient documentation to show that past practices involve predominantly the use of off-road engines in yard hostlers, then an off-road engine emission factor baseline can be used.

Emission levels are calculated by multiplying the engine emission factor by a conversion factor and an activity level, or

*Annual NOx emissions = NOx[g/bhp-hr] * Activity * Conversion Factor*

For off-road equipment, the activity level is either the annual hours of operation or annual fuel consumed. Records are required to be maintained over the life of the project in order to determine actual emission reductions achieved by the program.

When actual annual hours of equipment operation are the basis for determination of emission reductions, the appropriate conversion factor is the horsepower rating of the engine and an engine load factor, or

*Annual NOx emissions = NOx[g/bhp-hr] * Activity[hrs/yr] * Engine Rating[hp] * Load Factor*

Annual hours of equipment operation for determining emission reductions must be based only on readings from an installed and fully operational hour meter. A properly functioning hour meter is required to support equipment activity information included in an application for CMP funding. The engine load factor is an indicator of the nominal amount of work done by the engine for a particular application. It is given as a fraction of the rated horsepower of the engine and varies with engine application. When an actual load factor is known for a specific application, the CMP applicant may justify its use for calculating emission reductions to ARB and the local district by submitting appropriate and sufficient documentation. If a load factor is not known, the default load factors for off-road equipment in agricultural and construction applications listed in Table 3.5 must be used. The adopted OFFROAD emission inventory model reflects load factors ranging from 0.43 to 0.78 both heavy-duty diesel engines in agricultural and construction applications. For applications or equipment not listed in Table 3.5, a default load factor of 0.43 must be used.

The use of California's diesel fuel since 1993 (0.05 percent sulfur content by weight and 10 percent aromatic content by volume) would result in additional NOx and PM emissions from diesel engines compared to the base emission rates. Base emission rates for diesel engines, as embodied in OFFROAD and presented in Table 3.4 for uncontrolled engines, were derived from test data using either federal diesel fuel (0.05 percent sulfur content by weight) or pre-1993 diesel fuel. Federal diesel fuel is also used for new engine certification to comply with the emission standards shown in Table 3.1. Thus, a fuel adjustment factor needs to be applied to the base emission rate, for both uncontrolled and emission-certified engines, to more accurately reflect the emissions from diesel engines when those engines are operated using California diesel fuel. Table 3.6 shows the fuel adjustment factors to be used for off-road diesel engines.

Table 3.5. Default Load Factors for Off-Road Heavy-Duty Diesel Engines In Agricultural and Construction Applications.

Category	Equipment Type	Load Factor
Agriculture	Agricultural Mowers	
	Agricultural Tractors	
	Balers	
	Combines	
	Hydro Power Units	0.48
	Sprayers	0.5
	Swathers	0.55
	Tillers	0.78
	Other Agricultural Equipment	0.51
Construction	Cranes	0.43
	Crawler Tractors	0.64
	Crushing/Processing	0.78
	Excavators	0.57
	Graders	0.61
	Off-Highway Tractors	0.65
	Off-Highway Trucks	0.57
	Pavers	0.62
	Other Paving Equipment	0.53
	Rollers	0.56
	Rubber-Tired Dozers	0.59
	Rubber-Tired Loaders	0.54
	Scrapers	0.72
	Signal Boards	0.78
	Skid Steer Loaders	0.55
	Surfacing Equipment	0.45
	Tractors/Loaders/Backhoes	0.55
	Trenchers	0.75
	Other Construction Equipment	0.62

Table 3.6 Fuel Correction Factors (Off-road Diesel Engines)

Model Year	NOx	PM
Pre – Tier I	0.94	0.80
Tier I +	0.87	0.90

When annual fuel consumption used for determining emission reductions, the equipment activity level must be based, preferably, on actual annual fuel receipts, or other similarly appropriate documentation provided by the applicant. In this approach, an energy consumption factor must be determined to allow conversion of emissions given in g/bhp-hr to units of grams of emissions per gallon of fuel used (g/gal). The energy consumption factor may be determined by: 1) dividing the horsepower rating of the engine by its fuel economy expressed in units of gallons per hour (gal/hr), or 2) dividing the energy density of the fuel (in units of BTU/gal) by the brake-specific fuel consumption of the engine. While actual fuel receipts support the annual fuel consumption of the existing baseline engine, the annual fuel consumption of the replacement, reduced-emission engine is an estimate. A correction to account for the differences in the energy content corresponding to different fuels may be introduced. For example, a replacement engine having an energy content factor of 20 hp-hr/gal, which replaces an existing engine consuming 3,696 gal/yr and having an energy content of 18.5 hp-hr/gal, would have an estimated annual fuel consumption of 3,419 gal/yr, or

*(3,696 gal/yr) * (18.5 hp-hr/gal) / (20 hp-hr/gal) = 3,419 gal/yr*

Future fuel receipts or equivalent documentation must be submitted to the local district throughout the project life for verification.

<u>Cost-Effectiveness Calculation</u>
The only portion of the cost for a repower project eligible for CMP funding is the difference between the total installed cost of the replacement emission-certified engine and the total cost of either rebuilding the existing engine or purchasing a conventional replacement engine. Only the funding provided by the CMP and any local district matching fund enter into the C/E calculations. The one-time incentive grant must be amortized over the expected project life (at least five years) assuming a discount rate of 3%. The amortization formula given below yields a capital recovery factor (CRF), which, when multiplied by the initial capital cost, gives the annual cost of a project over its expected lifetime.

$$\text{Capital Recovery Factor (CRF)} = [(1 + i)^n (i)] / [(1 + i)^n - 1]$$

where,

i = discount rate (3%)
n = project life (at least five years)

Table 3.7 lists the CRF for different project lives based on a discount rate of 3%. The reader is referred to the previous chapter for a discussion on the revised discount rate of 3%. C/E for a project is determined by dividing the total annualized cost by the total annual NOx emission reductions. Sample calculations for off-road equipment projects are provided below.

Table 3.7 Capital Recovery Factors (CRF) for Various Project Lives
At 3% Discount Rate.

Project Life	CRF
5	0.218
6	0.185
7	0.161
8	0.142
9	0.128
10	0.117
11	0.108
12	0.100
13	0.094
14	0.089
15	0.084
16	0.080
17	0.076
18	0.073
19	0.070
20	0.067

Example 1
Construction Equipment Repower (Calculations Based on Hours of Operation)
An equipment owner applies for a CMP grant for the purchase of a new 2003 model year Tier 2 off-road diesel engine rated at 180 hp to replace a 1985 uncontrolled diesel engine rated at 150 hp used in a construction loader. The owner does not know the load factor for this application. Both the old and new engine will operate 700 hours annually and 100% of the time in California. The cost of the new emission-certified diesel engine is $16,000, whereas the cost to rebuild the existing engine is $8,000. Installation and re-engineering cost (to install the new engine into the existing equipment) is $6,000.

Emission Reduction Calculation
Existing Engine NOx Emission Factor (Table 3.4): 11 g/bhp-hr
Adjusted Existing Engine NOx Emission Factor (using fuel correction factor in Table 3.6):
(11 g/bhp-hr)(0.94) = 10.34 g/bhp-hr
Proposed Replacement Engine NOx+NMHC Emission Factor (Table 3.1): 4.9 g/bhp-hr
Adjusted Replacement Engine NOx Emission Factor (using default NOx fraction in Table 3.2 and fuel correction factor in Table 3.6): (4.9 g/bhp-hr)(0.95)(0.87) = 4.05 g/bhp-hr NOx
Existing (Baseline) Engine Horsepower: 150 hp
Replacement Engine Horsepower: 180 hp
Baseline Load Factor (Table 3.5): 0.55
Replacement Engine Load Factor: 0.55(150hp/180hp) = 0.46
Annual Hours of Operation: 700 hours
% Operated in CA: 100%

Hence, the estimated reductions are:
Baseline Engine:
(10.34g/bhp-hr * 0.55 * 150 hp) * 700 hrs/yr * 100% * ton/907,200 g = 0.66 t/yr
Reduced-Emission Engine:
(4.05 g/bhp-hr * 0.46 * 180 hp)* 700 hrs/yr * 100% * ton/907,200 g = 0.26 t/yr

NOx Emission Reductions: 0.66-0.26=0.40 tons/year NOx emissions reduced

Cost-Effectiveness Calculations

The annualized cost is based on the incremental project cost of the repower project, the expected life of the project (7 years default life), and the interest rate (3%) used to amortize the project cost over the project life. The incremental capital cost to the equipment owner for this purchase and the maximum amount of CMP funding are determined as follows:

Total installed cost of new engine:	\$ 16,000 + \$ 6,000 = \$ 22,000
Incremental Capital Cost:	\$ 22,000 - \$ 8,000 = \$ 14.000
Max. Amount Funded:	\$ 14,000
Capital Recovery (Table 3.7):	$[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 - 1] = 0.161$
Annualized cost:	(0.161)(\$ 14,000) = \$ 2,254/year
Cost-Effectiveness:	(\$ 2,254/year)/(0.40 tons/year) **= \$5,635/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project would qualify for the maximum amount of grant funds requested.

Example 2

Agricultural Harvester Repower (Based on Fuel Consumption)

An equipment owner applies for CMP funding for the purchase of an OEM remanufactured off-road diesel engine certified to Tier 1 emission standards (170 hp, 6.9 g/bhp-hr NOx) to replace an uncontrolled diesel engine (1980, 200 hp, 11 g/bhp-hr NOx) used in a harvester. The installed cost of the replacement emission-certified diesel engine is $9,500, whereas, the cost to rebuild and install the existing engine is approximately $6,900. The existing engine consumes 4,600 gallons of diesel fuel annually. The replacement engine will operate 100% of the time in California.

Emission Reduction Calculation

Existing (Baseline) Engine NOx Emissions: 11.0 g/bhp-hr

Adjusted Existing Engine NOx Emission Factor (using fuel correction factor in Table 3.6):
(11 g/bhp-hr)(0.94) = 10.34 g/bhp-hr

Baseline Energy Content Factor: 17.0 hp-hr/gal

Baseline Annual Fuel Consumed: 4,600 gallons

Replacement Engine NOx Emissions: 6.9 g/bhp-hr

Adjusted Replacement Engine NOx Emission Factor (using fuel correction factor in Table 3.6):
(6.9 g/bhp-hr)(0.87) = 6.0 g/bhp-hr NOx

Replacement Engine Energy Content Factor: 18.5 hp-hr/gal

Replacement Engine Annual Fuel Consumed ((4,600)(17/18.5)): 4,227 gallons

% Operated in CA: 100%

(ton/907,200 g): Converts grams to tons

Hence, estimated annual NOx reductions are:

Baseline Engine:

(10.34 g/bhp-hr * 17.0 bhp-hr/gal * 4,600 gal/yr) * 1.0 * ton/907,200 g = 0.89 tons/year

Replacement Engine:

(6.0 g/bhp-hr * 18.5 hp-hr/gal * 4,227 gal/yr)] * 1.0 * ton/907,200 g = 0.52 tons/year

NOx Emission Reductions: 0.89-0.52=0.37 tons/year NOx emissions reduced

Cost-Effectiveness Calculations

The annualized cost is based on the incremental proj **Example 1**

Construction Equipment Repower (Calculations Based on Hours of Operation)

An equipment owner applies for a CMP grant for the purchase of a new 2003 model year Tier 2 off-road diesel engine rated at 180 hp to replace a 1985 uncontrolled diesel engine rated at 150 hp used in a construction loader. The owner does not know the load factor for this application. Both the old and new engine will operate 700 hours annually and 100% of the time in California. The cost of the new emission-certified diesel engine is $16,000, whereas the cost to rebuild the existing engine is $8,000. Installation and re-engineering cost (to install the new engine into the existing equipment) is $6,000.

ect costs funded by the CMP, the expected life of the project (5 years at a minimum), and the interest rate of 3% used to amortize the project cost over the project life. Incremental capital costs to the fleet operator and the maximum eligible CMP funding are determined as follows:

Incremental Capital Cost:	$ 9,500 - $ 6,900 = $ 2,600
Max. Amount funded from Carl Moyer Program:	$ 2,600
Capital Recovery (Table 3.7):	$[(1 + 0.03)^5 (0.03)]/[(1 + 0.03)^5 - 1] = 0.218$
Annualized cost:	(0.218)($ 2,600) = $ 567/year
Cost-Effectiveness:	($ 567/year)/(0.37 tons/year) **= $1,532/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project would qualify for the maximum amount of grant funds requested.

Reporting and Monitoring

The district will continue to have the authority, and is encouraged, to conduct periodic checks or solicit operating records from the grantee of CMP funds for new off-road equipment purchases, equipment repowering, or engine retrofit projects. Monitoring of project progress ensures that the equipment or engine is operated as stated in the program application. Off-road equipment operators participating in the CMP are required to keep appropriate records during the life of the funded project. Records must contain, at a minimum, total hours of operation, fuel usage, and maintenance and repair information. Records must be retained and updated throughout the project life and made available at the request of the district or ARB.

Chapter Four
LOCOMOTIVES

This chapter presents the project criteria for projects involving locomotives under the revised CMP guidelines. It also contains a brief overview of the locomotive industry, emission inventory, current emission standards, available control technology, potential incentive projects eligible for funding, recommended emission reduction calculations, and estimated cost benefits.

INTRODUCTION

Traditionally, emission reductions have been sought from stationary and mobile on-road sources. Off-road sources, such as locomotives, also contribute to California's air pollution problems, but have not been regulated in California until recently. However, locomotives have been subject to various locally enforced opacity limits. Federal law prohibits California from setting standards for new locomotives and new engines used in locomotives. The U.S.EPA, with its sole authority to regulate emissions from locomotives, has adopted standards for locomotives to be phased-in beginning in 2000.

Participating railroads proposed to the U.S.EPA and ARB the establishment of a locomotive fleet average emissions program in the South Coast non-attainment area tied to the promulgation of the U.S.EPA National Locomotive Rule. ARB, U.S.EPA, and the participating railroads committed to develop this program, known as the South Coast Locomotives Program, by signing a Statement of Principles (SOP) in May 1997. Following the signing of the SOP, the railroads, U.S.EPA, and ARB discussed improvements and refinements of the program. In July 1998, a second agreement was signed that affects the in-use locomotive fleet in the South Coast non-attainment area. That agreement is a Memorandum of Understanding (MOU) signed by the ARB and participating railroads, agreeing to a voluntary locomotive fleet average emissions program that will speed the introduction of new, lower-emitting engines in the South Coast Air Basin.

EMISSIONS INVENTORY

The primary business of railroads is transportation of freight and passengers. Locomotives provide line-haul, local (short-line), switchyard (switchers), and passenger services. In California, line-haul transportation is the primary function of the Union Pacific Railroad Company and the Burlington Northern and Santa Fe Railway Company. These companies transport goods between major urban centers, sometimes over 1,000 miles apart. Reliability is an important factor when transporting goods over large distances. Locomotive "down-times" are expensive and can result in loss of revenue. Hence, line-hauls are well maintained, with engine remanufacture occurring every seven to eight years.

Typically, locomotives are well maintained and have a long useful life. Engines that are over 3000 hp and no longer suitable for line-haul service are typically designated for other services out of California, or even out of the United States. Engines that are less than 3000 hp and no longer suitable for line-haul services are usually re-assigned to the short-line fleets, and subsequently to the switchyards. Short-lines have smaller engines than line hauls since these locomotives carry smaller loads and travel shorter distances. Normally, short-line trips are under 200 miles and generally remain within the same geographic area. Short-lines are an older locomotive fleet, mostly predating the 1973 model year. Switch-yard locomotives are usually the oldest locomotives, and require the least amount of travel and work. Switchers typically distribute and re-arrange cars within the switchyard, port, or industrial facility and generally do not move beyond its normal work area.

There are approximately 20,000 locomotives in the U.S and about 1,200 (or 6%) are in California. Of these 1,200 locomotives, approximately 250 are used locally, 200 are used in switchyards, 100 are passenger trains, and the remaining 650 are used as line-hauls [EFEE 1995]. Locomotives generated approximately 3% to 4%t of the 1990 baseline NOx emissions in the South Coast Air Basin [ARB January 1991]. Table 4.1 lists updated baseline NOx emissions for 1990, 2005, and 2010.

Table 4.1. Baseline Locomotive NOx Emissions [a] (tons/day)

Area	1990	2005	2010
South Coast	30	31	17[b]
Statewide	160	106	78[b]

[a] Updated emission estimates from the ARB's emission inventory.
[b] Reflect the emission benefits of the South Coast MOU for locomotive fleets in Southern California.

EMISSION STANDARDS

U.S.EPA adopted emission standards for locomotives nationwide in December 1997. The standards took effect in the year 2000. Federal standards apply to locomotives originally manufactured in 1973 and later and any time they are rebuilt or remanufactured. Electric locomotives, historic steam-powered locomotives, and locomotives originally manufactured before 1973 are not regulated. Table 4.2 contains the federal exhaust emission standards for locomotives promulgated by the U.S.EPA [U.S.EPA 1997]. Emission standards for short-line and line-hauls are both based on the line-haul duty cycle.

Table 4.2. Federal Exhaust Emission Standards for Locomotives Beginning in 2000 for New Engines and at Time of Remanufacture.

Duty-cycle	Gaseous and Particulate Emissions (g/bhp-hr)			
	HC	CO	NOx	PM
	Tier 0 (1973 – 2001 model years)			
Line-haul duty-cycle	1.00	5.0	9.5	0.60
Switch duty-cycle	2.10	8.0	14.0	0.72
	Tier 1 (2002 – 2004 model years)			
Line-haul duty-cycle	0.55	2.2	7.4	0.45
Switch duty-cycle	1.20	2.5	11.0	0.54
	Tier 2 (2005 and later model years)			
Line-haul duty- cycle	0.30	1.5	5.5	0.20
Switch duty-cycle	0.60	2.4	8.1	0.24

CONTROL TECHNOLOGY

Although locomotives and their engines are expensive, they are designed to last a long time. Typical lifetimes are 25 and 30 years. Over this life, they are overhauled several times and repowered at least once. In general, locomotive engines are well maintained and the emissions associated with these engines typically remain the same over their lifetime.

The desire to improve fuel economy has influenced the development of advanced locomotive technologies. As a result, locomotive exhaust emission levels have generally been reduced with the development of new engine technologies. These technologies are somewhat similar to those for on-road HDV control technology. Technologies include, but are not limited to, turbocharging and aftercooling for NOx control, and improved fuel injection and combustion chamber redesign for PM and HC control.

Reduction in the time that a locomotive engine spends idling can provide real reductions in NOx, PM, CO and HC emissions. Devices are currently available that limit the free idle time of locomotive engines. Typically, a central computer monitors vital engine parameters and shuts off the prime mover when feasible. In addition, within the switcher industry, hybrid electric and battery electric locomotives have become available. Both types have the potential to provide large emission reductions as well as reduce operating and maintenance costs.

PROJECT CRITERIA

The CMP project criteria for locomotives have been revised to provide participating districts with a list of minimum requirements. Applicants must meet these qualifications in order to ensure that reduced-NOx locomotive projects result in surplus, real, quantifiable, and enforceable emission reductions over the life of the project. The revised program guidelines also provide districts and program operators with sample calculations to determine emission reductions and C/E for the proposed locomotive project. Reduced-NOx locomotive engine projects that include new or repowered engine replacement or existing engine retrofit will be considered for funding. In general, project selection is based on the amount of emission reductions, C/E, and the potential for project completion within the specified timeframe. Locomotive projects that meet at a minimum the following criteria would qualify for CMP funding. Participating districts retain the authority to impose additional requirements in order to maximize air quality benefits at the local level.

- Any emission reductions achieved through the CMP cannot be used for compliance with any memoranda of agreement/understanding or any other legally binding agreement.

- All NOx reductions from locomotive engines achieved with CMP funding must be beyond what may be required from a participating local air district by any federal, state, or local regulations or any other legally binding agreement.

- Locomotive engine emissions must be determined following the most current and approved U.S.EPA emission testing procedures for locomotives.

- Pre-1973 model year locomotive projects must result, based on emissions testing, in a minimum 15% reduction of NOx emissions from the uncontrolled baseline levels for the existing engine.

- Locomotives model year 1973 and later must meet Federal Tier 1 or Tier 2 locomotive NOx standards based on emissions testing.

- The acceptable maximum project life for calculating project benefits are as follows:

	Default without Documentation	Default with Documentation
A new locomotive project	20 years	30 years
A repower or retrofit project	20 years	30 years

  Project life beyond the "default without documentation" limits may be submitted for approval by ARB.

- Reduced emission levels must be maintained for a minimum of 5 years.

- 75% of estimated annual miles traveled and annual fuel consumption must occur in California.

- CMP funds cannot be expended on costs for labor or parts used during routine maintenance.

- Cost effectiveness must be no more than $13,600 per ton of NOx reduced.

- Locomotive projects that fall outside of these criteria, such as low-NOx fuel injectors and idle-limit devices (ILD) discussed below, may be considered on a case-by-case basis if evidence provided to the air district suggests potential, surplus, real, quantifiable, and enforceable emission reduction benefits.

TYPES OF POTENTIAL PROJECTS

Typical projects eligible for CMP incentive funding include repower or retrofit of an existing locomotive engine to reduce NOx emissions, purchase of a new reduced-NOx engine, installation of idle-limiting devices or verified reduced-NOx fuel injectors, or other alternative technology that has been verified by ARB to provide surplus, real, quantifiable, and enforceable emission reductions. Repower and retrofit projects may include the use of control technologies such as selective catalytic reduction (SCR), dual-fuel NG engine retrofits, turbocharging, and aftercooling. There may be other promising technologies that offer real emission reductions, but that are not yet certified for sale in California. ARB may consider these options on a case-by-case basis upon receipt of appropriate supporting documentation provided by the applicant through the local air district. Starting in 2000, when the federal standards took effect, ARB gained the ability to grant experimental permits for operation in California to promising technologies. Application for an experimental permit is based on evidence submitted by the applicant and meticulous assessment by ARB to ensure that only technologies that offer real emission reductions are deployed.

Reliability of a line-haul engine is extremely important. Since some of the control technologies are costly and have not been in wide use for locomotive engines, line-haul participation in the CMP is not expected until these technologies are proven effective and reliable on passenger, short-line, and switcher locomotive engines. Therefore, the ARB expects eligible reduced-NOx locomotive projects may be limited to passenger, short-line, and switchyard locomotives.

Repowers

Repowering can occur during engine remanufacture by exchanging the existing locomotive engine and replacing it with a new or newer, lower-emitting engine. An eligible repower project must result in NOx emission reduction of, at least, 15% from the existing engine levels. Emissions must be determined following U.S.EPA-approved test procedures for locomotive engines. In addition, emission reductions must be maintained for a minimum project life of 5 years.

Projects involving a pre-1973 model year locomotive engine must demonstrate NOx emission reductions of, at least, 15% below the uncontrolled baseline NOx levels for the existing engine. Baseline emission levels are listed in Table 4.3 below. Since there are no line haul locomotives in service in California with pre-1973 engines, qualifying projects are likely to be for switchers. Projects involving 1973 model year and later locomotives must consist of engines meeting to the federal Tier 1 or Tier 2 locomotive NOx standards as listed in Table 4.2. Engine emission testing must be conducted according to approved federal test procedures for locomotives.

Table 4.3. Baseline NOx Emission Factors and Maximum NOx Limits (g/bhp-hr).

Engine Model Year	Source	Line-haul	Switcher
Pre-1973	Uncontrolled Baseline Emission Factor	16 [a, b]	16.9 [b]
1973 and later	Baseline Emission Factor	9.5	14.0

[a]There are no line haul locomotives in service in California that are pre-1973, baseline emissions are listed for short-line locomotives only.
[b]ARB emission rates are average estimates based on data provided by engine manufacturers.

Retrofits

Retrofit involves hardware modifications to the engine to result in lower exhaust emissions. Typical retrofits involve the addition of control equipment or conversion to alternative fuel. CMP funding is available for locomotive retrofit projects that result in real NOx emission reductions and meet a maximum C/E of $13,600 per ton of NOx reduced. Similar to repowers, in order to qualify for funding, locomotive engines must be tested to a reduced-NOx emissions level following accepted U.S.EPA test procedures for locomotives. In addition, lower emission levels must be maintained for a minimum of 5 years (project life).

The allowable NOx emissions limits for line-haul and switcher locomotives using retrofit kits are the same as for repower locomotive projects. Pre-1973 model year locomotive engine must demonstrate NOx emission reductions of, at least, 15% below the uncontrolled baseline NOx levels for the existing engine. Baseline emission levels are listed in Table 4.3 below. Projects involving 1973 model year and later locomotives must consist of engines meeting to the federal Tier 1 or Tier 2 locomotive NOx standards as listed in Table 4.2.

Replacement of Fuel Injectors

The replacement of fuel injectors with those that provide NOx emission reductions of at least 15% will be considered for the CMP. Eligibility is based on the amount of emission reductions and a maximum C/E of $13,600 per ton NOx reduced. Similar to repower and retrofit projects, in order to qualify for funding, locomotive engines must be emission-tested according to U.S.EPA test procedures for locomotives to determine NOx emission reductions. The emission reduction benefits must be maintained for a minimum of 5 years (project life).

Funding for low-NOx fuel injector technology is available for pre-1973 model year switchers or short-line locomotive engines. Only fuel injector technology that has been evaluated or verified by the ARB as a NOx reduction strategy is eligible for funding. Stock fuel injector replaced with those that provide NOx emission reductions normally also produce large PM emission reductions. Advanced NOx emission reducing fuel injectors are expected to provide fuel savings of approximately 1-3%. Since typical fuel injectors have a useful life of approximately one year, the applicant must commit to use the specified low-NOx injectors for a minimum of five years, one set per year. The funding allocation will be proportional to the number of years committed to the project by the applicant. The funding allocation will be, at a maximum, for the incremental cost between stock injectors and emission reducing injectors evaluated by the ARB. The applicant must also include with their application a signed commitment that the all related engine operating parameters, such as injector timing, remain at the setting used during emission testing. This requirement ensures that the verified 15% or greater NOx emission reduction is achieved with the new efficient injectors for the life of the project. These criteria are subject to verification by the air district or its designee at any time. It is suggested that engine timing adjustments that are used to ensure the application-specified NOx emission reduction be accomplished by timing adjustments within the fuel injector itself.

Idle Limit Devices

Locomotive ILD may be considered for CMP funding under the revised guidelines. Idle limit devices will be required to satisfy the program requirements similar to those for auxiliary power units (APU) for heavy-duty vehicles. Those requirements are:

- Eligible projects must provide at least 15% NOx emission benefit compared to baseline idling NOx emissions.

- NOx reductions obtained through this program must not be required by any existing regulations, memoranda of agreement/understanding, or other legally binding documents.

- All ILD and any other auxiliary devices must comply with applicable durability and warranty requirements. An engine used for auxiliary power must meet current emission standards and be verified by the ARB for sale in California.

- An hour-meter must be installed with the APU or IDL to record the actual operating time of the APU or ILD and to provide information on the number of hours the APU or ILD is utilized.

- If locomotive idling is offset by an engine used in an APU, the load factor for the APU engine will be its maximum power rating. Other load factor may be proposed and supported by proper documentation.

- Funded projects must operate for a minimum of 5 years and emission benefits would be based on the locomotive's idling time of which at least 75% must occur in California.

- The lower amount of actual installation costs of the APU or ILD including an hour meter, or up to a maximum of $1,600 per diesel APU installation and a maximum of $3,100 per ILD, or alternative fuel, electric motor, or fuel cell APU installation may be funded.

- The equipment costs of a locomotive-specific IDL up to a maximum of $5,000.

- Projects must meet a cost-effectiveness criterion of $13,600 per ton of NOx reduced.

The project's IDL or APU installation cost of $3,100 is limited by the maximum funding allowed by the requirement stated for auxiliary power units (See Chapter 10, Auxiliary Power Units for Reducing Idling Emissions from Heavy-duty Vehicles). The locomotive-specific IDL equipment cost limit was based on an average IDL cost of approximately $7,500 per unit and a cost-share requirement of $1 from the applicant for every $2 of CMP funding.

Advanced Locomotive Technology

Within the switcher industry great advances are being gained in hybrid and battery electric technology. Rail Power Technologies' Green Goat™ has been under a one-year evaluation at Union Pacific's Roseville, CA yard starting in March of 2002. Large NOx and PM emission can be gained from the introduction of hybrid switchers at a cost that may be favorable relative to a new switcher. The applications for such a switcher are numerous. They include rail switchyards, port facilities, and industrial sites. Fuel use is dramatically reduced, as well as maintenance costs. In addition, battery electric switchers are currently available in the market place as a low horsepower diesel switcher alternative. These switchers utilize rechargeable batteries.

Advanced locomotive technologies that reduced emissions at a cost higher than conventional diesel powered locomotives may be considered for program participation. Similar to other eligible projects, air districts retain the ability to make assessments on a case-by-case basis. Projects deemed meritorious and meeting the C/E threshold of $13,600 may be considered for CMP participation.

Sample Application

Districts solicit bids for reduced-emission projects from off-road diesel equipment operators and make applications available upon request. A sample application form is included in the Appendix. The applicant must provide the minimum information illustrated in Table 4.4. Air district can request additional information.

Table 4.4. Minimum Application Information Locomotive Projects.

1. Air District: 2. Applicant Demographics Company Name: Business Type: Mailing Address: Location Address: Contact Number: 3. Project Description Project Name: Locomotive Type: Engine Type: Vehicle Class: 4. Annual Ton-Miles: 5. Project Life (years): 6. Old Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year: Fuel Injector Type: 7. New Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year: Fuel Type: Fuel Injector Type: Added Equipment:	8. NOx Reduction Incremental Cost Effectiveness Analysis Basis: (Mileage/Fuel/Hours of Operation) 9. VIN or Serial Number: 10. Application: (Repower, Retrofit or New Install) 11. Percent Operated in California: 12. Percent Operated in Air District: 13. Annual Diesel Gallons Used: 14. Fuel Consumption Rate: 15. NOx Emissions Reductions Baseline NOx Emissions Factor (g/bhp-hr): NOx Conversion Factors Used: Reduced NOx Emissions Factor (g/bhp-hr): Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions: 16. Cost ($) of the Base Engine: 17. Cost ($) of Certified LEV Engine: 18. Cost ($) of NOx emission reducing equipment 19. PM Emissions Reductions Baseline PM Emissions Factor (g/bhp-hr): PM Conversion Factors Used: Reduced PM Emissions Factor (g/bhp-hr): Estimated Annual PM Emissions Reductions: Estimated Lifetime PM Emissions Reductions: 20.. District Incentive Grant Requested:

EMISSION REDUCTION AND COST-EFFECTIVENESS

Costs for emission control technology for locomotives vary greatly and depend on the particular scenario and technology involved. While capital costs for some reduced-NOx controls for locomotive engines can be high, they are still less than costs of a new engine. In other cases, some lower emissions technologies can actually create cost savings to locomotives. In the CMP, the amount of incentive funds for the incremental costs of the cleaner technology depends on emission reductions and the C/E limit of $13,600 per ton of NOx reduced.

Emission reductions for locomotives are based on annual fuel consumption or hours of operation and percent operated in California. If the applicant provides annual hours of operation, a fuel consumption rate must also be provided. Annual emissions must be estimated separately for the existing baseline engine and the replacement, new or modified, engine. Baseline activity levels relative to future activity levels must be considered. Annual diesel engine emissions are calculated by multiplying the NOx emission factor by an assumed energy consumption factor of 20.8 bhp-hr/gal and the estimated annual fuel consumption. The emission results for both engines are subtracted, multiplied by the percent operated in California, and converted from grams to tons [U.S.EPA 1997]. If annual hours of operation are provided, the annual fuel consumption is calculated by multiplying the fuel consumption rate by the annual hours of operation. The following formulas must be used when calculating project NOx reductions.

*Annual NOx Reductions (tons/year) = [(Ann. Fuel Cons. * Fuel Cons. Factor * Baseline NOx Emissions) – (Ann. Fuel Cons. * Fuel Cons. Factor * Reduced NOx Emissions)] * (% operated in CA) * (1 ton / 907,200 grams)*

where,

Ann. Fuel Cons =	Estimated Annual Fuel consumption for the existing and replacement (new or retrofitted) engine(gal/year). If not known, provide annual hours of operation and a fuel consumption rate.
Fuel Cons. Factor =	20.8 bhp-hr/gal for locomotive diesel.
Baseline NOx Emissions =	NOx emission factor for existing engine in g/bhp-hr.
Reduced NOx Emissions =	NOx Emission factor for replacement (new or retrofitted) engine in g/bhp-hr
% operated in CA =	The percent (as a fraction) of time operated in California
Conversion factor:	1 ton = 907,200 grams

Cost-effectiveness is based on the incremental capital cost, any matching funds that were used to fund the project, the expected life of the project, the interest rate (3%), and estimated annual NOx reductions in a particular district. The reader is referred to discussions provided in Chapter Two for the discount rate.

Incremental costs are determined by considering the difference between the capital cost to remanufacture an engine to its original configuration (without improved control technology) and the capital cost of the replacement lower-NOx engine (new, repower, or retrofit). The incremental capital cost is annualized using a CRF based on a 3% rate of return over the life of the project. Incremental costs are divided by the total annual NOx reductions to result in the project C/E. Large NOx reductions result in better C/E, which is determined as follows:

Incremental Project Cost = (Aft. Proj. Cap. Cost) - (Bef. Proj. Cap. Cost)

where,

Aft. Proj. Cap. Cost = capital costs for replacement, reduced-NOx engine
Bef. Proj. Cap. Cost = capital costs for the rebuilt engine without the upgrade

Maximum Amount Funded = (Incremental Project Cost) - (Matching Funds)

$$\text{Capital Recovery Factor(CRF)}=[(1 + i)^n (i)] / [(1 + i)^n - 1]$$

where,

i = discount rate (3%)
n = project life (at least five years)

*Annualized Cost = (Maximum Amount) * CRF*

C/E = Annualized Cost) / Annual NOx Reductions (ton/yr)

Example 1
Locomotive Engine Retrofit

Consider an operator faced with the opportunity to convert one locomotive engine during the normal remanufacture period. The railroad applies for funding for a locomotive compressed natural gas (CNG) retrofit kit for a 1972 short-line engine. The retrofit kit reduces uncontrolled emissions by 30%. Since it is usually about seven years until the next remanufacture, the project life is seven years. The railroad company estimates the remanufacture of the engine without the retrofit kit to be about $890,000. However, the upgrade is more expensive at $920,000. The railroad also estimates that the annual fuel consumption for this engine in California would be approximately 60,000 gals. Emission reductions are calculated using the formula listed above:

<u>Emission Reduction Calculation</u>

Annual Fuel Consumption:	60,000 gals/year
Baseline NOx Emissions:	16.0 g/bhp-hr
Reduced NOx Emissions:	11.2 g/bhp-hr (30 percent reduction from 16.0 g/bhp-hr)
Fuel Cons. Factor:	20.8 bhp-hr/gal
% operated in CA:	100%
Conversion factor:	1 ton = 907,200 grams

Estimated annual NOx reductions are:

[(60,000gal/year * 20.8 bhp-hr/gal * 16 g/bhp-hr) – (60,000 gal/year * 20.8 bhp-hr/gal 11.2 g/bhp-hr)] * 1 ton / 907,200 g) = **6.6 tons/year**

It is assumed that the replacement CNG retrofit has the same equivalent annual fuel consumption (60,000 gals/yr) and energy content (20.8 bhp-hr/gal) as the existing diesel engine. The capital and incremental costs and benefits can be calculated as follows:

Cost-Effectiveness Calculations

Capital Costs for remanufacture without Upgrade	$ 890,000
Capital costs for remanufacture with retrofit kit	$ 920,000
District Matching funds	$0

Incremental Project Cost:	($ 920,000 - $ 890,000) = $ 30,000
Maximum Amount Funded:	($ 30,000 - $ 0) = $ 30,000
Capital Recovery Factor:	$[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 – 1] = 0.161$
Annualized Cost:	($ 30,000) * (0.161) = $ 4,830/yr
Cost Effectiveness:	($ 4,830/yr) / (6.6 ton/yr) = **$ 732/ ton of NOx reduced**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project would qualify for the maximum amount of grant funds requested.

Example 2
Locomotive Engine Replacement

Consider an operator faced with the opportunity to replace a short-line locomotive engine during the normal remanufacture period. The railroad applies for funding to replace a 1983 short-line locomotive engine (9.5 g/bhp-hr NOx) with a liquefied natural gas (LNG) engine (4.0 g/bhp-hr NOx). The railroad company estimates a project life of 20 years for the LNG engine. The railroad company also estimates the normal remanufacture costs for the engine to be about $890,000. The LNG upgrade costs are $1.2 million. The railroad also estimates that the annual hours of operation for the new engine to be 1000 hours per year, with an average fuel consumption rate of 17.5 diesel equivalent gallons per hour. The annual fuel consumption of the existing engine is 14,000 gal/yr. Emission reductions are calculated as follows:

Emission Reduction Calculation

Replacement Engine Annual Fuel Consumption:	1000 hrs/yr * 17.5 gals/hr = 17,500 gal/yr
Baseline NOx Emissions:	9.5 g/bhp-hr
Reduced NOx Emissions:	4.0 g/bhp-hr
Energy Consumption Factor:	20.8 bhp-hr/gal
% operated in CA:	100%
Conversion factor::	1 ton = 907,200 grams

Estimated annual NOx reductions are:
[(14,000 gal/yr * 20.8 bhp-hr/gal * 9.5 g/bhp-hr) - (17,500 gal/yr * 20.8 bhp-hr/gal * 4.0 g/bhp-hr)] * 1 ton / 907,200 g = **1.4 tons/year**

Cost-Effectiveness Calculations

Capital Costs for remanufacture without Upgrade	$890,000
Capital costs for LNG engine	$1,200,000
Matching funds	$0

Incremental Project Cost: **$** 1,200,000 - $ 890,000 = $ 310,000
Maximum Amount Funded: **$** 310,000 – $ 0 = $ 310,000
Capital Recovery Factor: $[(1 + 0.03)^{20} (0.03)]/[(1 + 0.03)^{20} – 1] = 0.067$
Annualized Cost: ($ 310,000) * (0.067) = $ 20,770/yr
Cost Effectiveness: ($ 20,770/yr) / (1.4 ton/yr) = **$ 14,836/ ton of NOx reduced**

The cost-effectiveness for the example is greater than the $13,600 limit. In order to meet the $13,600 per ton cost-effectiveness requirement, this project would only qualify for part of the incremental cost - a maximum amount of approximately $284,000.

Example 3
Switcher Locomotive Fuel Injector Upgrade

Consider an opportunity to replace a model year 1972, 16 cylinder, switcher locomotive's fuel injector during the normal fuel injector replacement period with those that reduce fuel consumption by 1-3% and NOx emissions by 15% at a cost of $675 per cylinder. The railroad applies for funding to cover the incremental cost of the new, low-NOx, more efficient injectors relative to the cost of stock injectors. The typical lifetime for locomotive diesel injectors is approximately 6000 hours or one year of typical usage. Therefore, the railroad company must commit to use the new efficient injectors for a minimum of five years. The railroad buys new injectors for their switcher every year at a cost of $137 per cylinder. The railroad estimates that the pre-1973 switcher consumes 53,000 gallons of diesel fuel per year.

Emission Reduction Calculation

Baseline Annual Fuel Consumption: 53,000 gal/yr
Alternative Annual Fuel Consupmtion: 51,940 ga/yr (2% fuel savings due to advance injectors)
Baseline NOx Emissions: 16.9 g/bhp-hr
Reduced NOx Emissions: 14.4 g/bhp-hr (15% reduction)
Energy Consumption Factor: 20.8 bhp-hr/gal
% operated in CA: 100%
Conversion factor: 1 ton = 907,200 grams

Estimated annual NOx reductions are:
[(53,000 gal/year * 20.8 bhp-hr/gal * 16.9 g/bhp-hr) - (51,940 gal/year * 20.8 bhp-hr/gal * 14.4 g/bhp-hr)] * 1 * ton / 907,200 g = **3.4 tons/year**

Costs for stock injectors for 5 years	$10,960 ($137/cyl * 16 cyl * 5 yrs)
Costs for efficient injectors for 5 years	$54,000 ($675/cyl * 16 cyl * 5 yrs)
Matching funds	$0

Cost-Effectiveness Calculations

Incremental Project Cost: **$** 54,000 - $ 10,960 = $ 43,040
Maximum Amount Funded: **$** 43,040 – $ 0 = $ 43,040
Capital Recovery Factor: $[(1 + 0.03)^{5} (0.03)]/[(1 + 0.03)^{5} – 1] = 0.218$
Annualized Cost: ($ 43,040) * (0.218) = $ 9,383/yr
Cost Effectiveness: ($ 9,383/yr) / (3.4 tons/year) = **$2,760/ton of NOx reduced**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project would qualify for the maximum amount of grant funds requested.

Example 4 –Short-line Locomotive Idle Limit Device Retrofit: Consider an opportunity to install an idle limit device on a model year 1981 locomotive during routine maintenance. The rail company estimates that the locomotive idles about 47% of the total operating time. During that idle time, 20,000 gallons of diesel fuel are consumed. It is estimated that idle time can be reduced by 50% by the ILD, thereby, saving 10,000 gallons of fuel per year. The estimated lifetime for an ILD is 10 years.

<u>Emission Reduction Calculation</u>

Annual Fuel Consumption Reduced:	10,000 gal/yr
NOx Emissions Factor:	9.5g/bhp-hr
Energy Consumption Factor:	20.8 bhp-hr/gal
% operated in CA:	100%
Conversion factor:	1 ton = 907,200 grams

Estimated annual NOx reduction are:
[(10,000 gal/year * 20.8 bhp-hr/gal * 9.5 g/bhp-hr)*(1 ton / 907,200 g)] = **2.2 tons/year**

<u>Cost-Effectiveness Calculations</u>

Capital Costs for idle limit device	$8,000
Cost for installation	$4,000
Matching funds	$0

Project Cost:	$8000 + $ 4000 = $ 12,000
Maximum Amount Funded:	($5,000 + $3,100) – $ 0 = $ 8,100
Capital Recovery Factor:	$[(1 + 0.03)^{10} (0.03)]/[(1 + 0.03)^{10} – 1] = 0.117$
Annualized Cost:	($8,100) * (0.117) = $ 948/ year
Cost Effectiveness:	($948 /yr) / (2.2 ton/yr) = **$ 431/ ton of NOx reduced**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project would qualify for the maximum amount of grant funds requested.

Reporting and Monitoring

The district has the authority, and is encouraged, to conduct periodic checks and/or solicit operating records from the applicant that has received CMP funds. This is to ensure that the engine is operated as stated in the program application. The applicant must maintain operating records and have them available to the district or ARB upon request. Records must contain, at minimum, locomotive identification numbers, retrofit hardware model and serial numbers, estimated annual fuel consumption in the California, hours of operation in California, hours in idling mode, and maintenance/repair dates (or any type of servicing information), and any emission testing results. Records must be retained and updated throughout the project life and made available for district inspection.

Chapter Five
MARINE VESSELS

The marine industry is diverse, complex and only recently the focus of emission reduction strategies. Moreover, marine vessel operating parameters, emission characteristics, and emission control technology are not well understood. Nonetheless, marine vessels present an ideal application for CMP funding because there exist several means for significantly reducing their relatively high NOx emission levels. In the first three years the CMP, 182 marine vessel projects constituted about 8% (698 tons/year) of the total emission reductions generated from the CMP [ARB March 2002]. This chapter presents guidelines for CMP marine vessel applicants. It includes a brief explanation of the different types of marine engines, an overview of current emission standards and available control technology, and guidance regarding project selection, emission calculations, and cost effectiveness estimates.

BACKGROUND

Marine vessel engines contribute to emissions of NOx, HC, CO, PM, and SOx. Marine vessel traffic consists of foreign and domestic (U.S. based) fleets. Emissions from marine vessel engines are generated in California during vessel travel through defined California coastal waters, vessel calls on California ports, as well as from other vessel activities in and near the ports such as fishing, tugboat operations and work boats. Marine vessel fleets range in power, from approximately 500 to 67,000 hp. In 1993 approximately 1,500 vessels made 5,500 calls on the San Pedro Bay Ports in the South Coast. Approximately 94 percent of the 1,500 vessels were foreign and 6 percent were U.S. vessels. Of these, approximately 95% of the vessels calling on the San Pedro Bay Ports were propelled by diesel engines, with the remaining 5% relying on steam turbines.

CMP funding is available for commercial harbor craft - a subset of marine vessels – and ocean-going vessels. Historically, the CMP has funded exclusively commercial harbor craft. Thus, descriptions in this chapter are focused on commercial harbor craft. Eligible projects for ocean-going vessel will be considered on a case-by-case basis by ARB and district staff. The CMP continues to present an opportunity to realize near-term emission reductions from marine vessel by offering vessel owners incentives for voluntarily reductions of NOx emissions before mandated regulatory controls come in effect. Commercial harbor craft consists of small service and industrial vessels, tugboats, towboats, offshore supply boats, commercial fishing vessels, work boats, crew boats, certain Coast Guard and military vessels and passenger boats, including ferries and excursion boats. Commercial harbor craft are generally part of the California "captive fleet" meaning they stay within California coastal waters, usually departing and returning to the same port. The coastal water boundary for California consists of a range from 27 miles off of the California coast at the narrowest to 102 miles off the coast at the widest as illustrated in Figure 5.1. For the most part, commercial harbor craft use diesel-powered propulsion and auxiliary engines and run on distillate fuel (e.g., U.S. EPA on-road diesel fuel).

Unlike most recreational vessels, commercial harbor craft are typically displacement vessels (i.e., the engine pushes the vessel through the water rather than hydroplaning), which endure heavy use and operate up to 6,000 hours a year. Therefore, their engines are designed for prolonged operation at high loads. Because commercial harbor craft typically do not need high power bursts to initiate planing (as with most recreational boats), engine fuel efficiency is emphasized over power density.

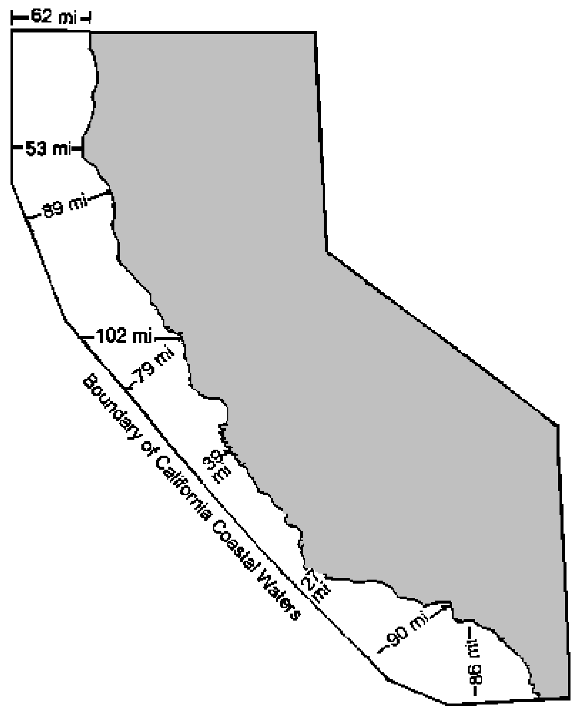

Figure 5.1. Coastal water boundaries from the California Air Resources Board's Report to the California Legislature on Air Pollutant Emissions from Marine Vessels, 1984.

Commercial marine vessels are diverse, operate under varied conditions and can accommodate a wider range of engine sizes and types than recreational vessels, which are often designed around a specific engine model. Consequently, commercial marine engines are available in a wider range of power ratings than their recreational or land-based counterparts. This diversity within the commercial marine engine market along with the absence of regulatory controls has resulted in wide range of emission outputs from existing marine vessels. The limited available data confirms large variations among marine vessel emission outputs while also revealing the fact that no engine or marine vessel characteristics are reliable predictors of NOx emission rates. Older engines often emit less than newer engines, larger ones less than smaller ones, and fast boats less than slow boats. Furthermore, marine vessel emission rates can be influenced by factors, such as the marinization process, that do not apply to their land-based counterparts. In the following sections we briefly discuss some of the factors that affect marine engine emission rates.

MARINE PROPULSION AND AUXILIARY ENGINES

The U.S. EPA distinguishes large (≥37 kW) marine diesel engines by size based on cylinder displacement. They divide marine engines into three distinct categories. Each category has a land-based counterpart. *Category 1* engines with a specific displacement of less than 5 liters per cylinder are similar to off-road diesel engines used in applications such as farm and construction equipment. Nationwide, commercial marine engines make up the majority of the Category 1 emissions accounting for approximately 85% of HC+NOx, even though they represent only 23% of the Category 1 engine population [.US.EPA, 1999]. This is due primarily to the high engine loads and long operating hours of commercial vessels. The U.S.EPA has further subdivided Category 1 engines for the purpose of showing their corresponding land-based engine types (see Table 5.1). To date, the vast majority of CMP funded marine vessel projects have been Category 1 engine replacements.

Table 5.1. Off-road Power Categories Corresponding to Per-Cylinder Displacement Ranges for Category 1 Marine Engines [Source: U.S.EPA, 1999].

Displacement (liters/cylinder) Power ≥ 37 kW	**Approximate Corresponding Power Band from Land-based Non-Road Rulemaking**	
displ. < 0.9	37 ≥ kW < 75	50 ≥ hp < 100
0.9 ≥ displ. < 1.2	75 ≥ kW < 130	100 ≥ hp < 175
1.2 ≥ displ. < 2.5	130 ≥ kW < 560	175 ≥ hp < 750
2.5 ≥ displ. < 5.0	kW ≥ 560	Hp ≥ 750

Table 5.2. EPA Marine Diesel Engine Categories.

Engine Category	**Category Displacement per Cylinder**	**Basic Engine Type**
1	disp. < 5 liters (and power ≥ 37 kW)	Nonroad
2	5 ≤ disp. < 30 liters	Locomotive
3	disp. ≥ 30 liters	Unique, “Cathedral”

Category 2 engines, with a specific displacement at or above 5 liters to 30 liters per cylinder are basically locomotive engines. “Category 3” engines are the largest marine

engines, used primarily in ocean-going ships. At 30 or more liters per cylinder, they are typical of powerplant generators. In the four years of existence of the CMP, there have been no applications for Category 3 vessels. Most of these vessels operate under foreign flags outside of California coastal waters. Therefore, operation within California waters must be verify in order to determine emission benefits. Commercial harbor craft typically utilize Category 1 and Category 2 marine diesel engines for propulsion and auxiliary power. The U.S.EPA marine diesel engine categories, which were used for developing emission regulations, are presented in Table 5.2.

Marine Engine Power Ratings

In conjunction with size, marine engine power ratings can also affect emission rates. The main engine power ratings used in commercial marine applications *are light-duty commercial, intermittent-duty commercial, medium continuous duty*, and *continuous duty***.** Light-duty commercial diesel engines are basically the same as recreational marine diesel engines, except they are generally more durable and heavier for a given power rating. They are used in applications that have relatively low load factors and require short power bursts and where high engine speeds are not maintained for long periods of time. Light-duty commercial engines -- typically Category 1 engines -- are often used in boats with planing hulls such as, patrol craft emergency rescue boats, fast ferries, and cruising yachts. They are also used for bow and stern thrusters in larger vessels.

Intermittent-duty commercial rated engines perform well under variable speeds and loads. They are used primarily for displacement hull service where engine load and speed are cyclical. These engines are designed to operate at full load and speed no more than half of the time and are often used in commercial fishing boats (e.g., lobster boats that move at high speeds), ferries, harbor tugs and short trip coastal freighters. They are typically Category 1 engines, but may include some Category 2 engines. Marine engines with a medium continuous rating are designed to operate for long periods at fairly constant speed and at, or near, full load. Engine load and speed are essentially constant with some cycling. Medium continuous duty engines provide good durability and fuel consumption while still maintaining some performance benefits. They are commonly found in applications such as crew and supply boats, trawlers, and towboats. This rating includes most Category 2 marine engines as well as some Category 1 engines.

Continuous rated, or constant speed marine engines, are designed to operate under full load up to 24 hours per day and generally operate more than 5000 hours per year. Engine load and speed are essentially constant without interruption. These engines are designed to achieve the lowest possible operating cost, which means maximizing durability and fuel efficiency. Typical applications range from tugboats to ocean-going vessels. Tugboat applications often use Category 2 engines while the majority of ocean-going vessels use Category 3 engines.

Marine Auxiliary Engines

All three categories of marine diesel engines are also used for auxiliary power onboard marine vessels. Most commercial harbor craft use Category 1 intermittent-duty engines, although larger category 2 medium continuous rated engines are also used. Auxiliary engines, which generally have a much different duty cycle than propulsion engines, are used to generate electricity on board for navigational and crew services, lights, onboard cabin temperature regulation, and on-deck equipment such as cargo cranes.

Many marine vessels have two or more auxiliary engines. In fact, all passenger vessels are required by the U.S. Coast Guard to have at least two auxiliary engines. In the case where more than one engine is available, the usage pattern of the engines is left to the discretion of the ship operator. For example, a ship operator with two auxiliary engines (and excess power generating capacity) could use each engine on alternate days, both simultaneously at partial load, or one particular engine for all onboard power generation designating the second as an emergency backup. How the engines are used can have a significant impact on overall emission rates.

Engine Marinization

Marine engines are basically land-based engines that undergo a “marinization” process performed by either engine manufacturers or post-product marinizers. The marinization process is necessary to adapt a land-based engine to marine applications. The most significant changes made to the land-based engines concern the cooling system. Whereas off-road equipment and locomotive engines are severely constrained in their heat rejection capabilities, marine engines have the advantage of being able to use the cold water as a large heat sink (although there is no air flow around the engine).

Aftercooling reduces NOx by lowering the temperature of the charge air compression. Reducing the charge air temperature directly reduces the peak cylinder temperature during combustion which, in turn, reduces NOx formation. Two different types of water after-cooling strategies are commonly used in marine engines – jacket-water and raw water-aftercooling. Although these technologies are used primarily for enhanced safety and engine performance, they also reduce NOx output.

In addition to water aftercooling, many other modifications are often made to engines during the marinization process such as changes to camshaft, piston and cylinder head configurations, fuel injection systems, and air injection timing. Even the lubrication system can be altered. In addition, marinization also involves replacing engine components with those made of materials that are more conducive to the marine environment (e.g., more corrosive-resistant). All these marinization changes are for the benefit of prolonging engine life, increasing safety and improving engine efficiency. Because marine engines have been unregulated, manufacturers and marinizers have not had to worry about controlling emissions. Consequently, engine marinization can result in a net increase *or* decrease of NOx emissions.

MARINE EMISSION STANDARDS AND EMISSION REDUCTION STRATEGIES

Until now marine vessels emissions have been unregulated, but recently actions have been taken at both the international and national level to curb their emissions. However, the full effect of even these modest emission reductions will not be realized for many years since the ensuing regulations apply primarily to new engines. The CMP provides an opportunity for more significant near-term emission reductions. The following section describes the relevant national and international marine emission regulations as well as other proposed strategies that could affect CMP funding eligibility.

International Maritime Organization (IMO) Regulations

The International Maritime Organization established NOx standards in Annex VI to the International Convention for the Prevention of Pollution from Ships in 1997. The standards apply to diesel engines over 130 kW (174 hp) installed on new vessels (ocean-going ships). As shown in Table 5.3 below, the NOx standards range from 9.8 to 17 g/kW-hr, depending on the rated engine speed.

Table 5.3. IMO NOx Standards

Engine Speed (rpm)	NOx (g/kW-hr)	NOx (g/bhr-hr)
$n < 130$	17.0	12.7
$130 \leq n < 2000$	$45n^{(-0.2)}$	(convert from g/kW-hr)
$n \geq 2000$	9.8	7.3

The IMO standards do not become enforceable until ratified by 15 countries that represent at least 50% of the gross tonnage of the world's merchant shipping. To date, this has not happened, and the United States is among the countries that have not ratified these standards. However, the standards are retroactive to January 1, 2000, if ratified, and so engine manufacturers have generally produced IMO compliant engines since that date.

U.S. EPA Standards

The U.S.EPA promulgated exhaust emission standards for new diesel engines over 37 kW (50 hp) on December 29, 1999 (64 FR 73301). The standards apply primarily to commercial harbor craft because the rule exempts recreational craft and the large "category 3" engines (over 30 liters per cylinder) used by most ocean-going vessels. There is a standard for PM, CO and a combined standard for NOx and ROG. As shown in Table 5.4 below, the specific standard and implementation date depends on the engine cylinder displacement. The NOx+THC standards range from 7.2 to 11 g/kW-hr. The implementation dates range from 2004 to 2007, depending on engine size.

Based on available test data [U.S.EPA, 1999], it is estimated that NOx constitutes approximately 95%-97% of the combined THC+NOx emissions for existing marine engines. However, in order to meet the new EPA standards, engine manufacturers will likely change marine engine performance to more closely match on-road engines. In this case, higher THC will be traded-off to achieve lower NOx. Therefore, for engines certified using a combined THC+NOx standard, it is assumed for the purpose of CMP project evaluations, that NOx will comprise 95% of the combined emissions.

Table 5.4. U.S. EPA "Tier II" Marine Diesel Emission Standards.

Engine Category	Displacement (liter/cyl)	Starting Date	NOx+THC (g/kW-hr)	PM (g/kW-hr)	CO (g/kW-hr)
1	D < 0.9	2005	7.5	0.40	5.0
	0.9 ≤ D < 1.2	2004	7.2	0.30	5.0
	1.2 ≤ D < 2.5	2004	7.2	0.20	5.0
	2.5 ≤ D < 5.0	2007	7.2	0.20	5.0
2	5 ≤ D < 15	2007	7.8	0.27	5.0
	15 ≤ D < 20 (P < 3300 kW)	2007	8.7	0.50	5.0
	15 ≤ D < 20 (P ≥ 3300 kW)	2007	9.8	0.50	5.0
	20 ≤ D < 25	2007	9.8	0.50	5.0
	25 ≤ D < 30	2007	11.0	0.50	5.0

Auxiliary engines on marine vessels are subject to the harmonized ARB/U.S.EPA off-road CI engine standards for NOx. These standards and their implementation dates were presented previously in Chapter 3. They are listed in Table 5.5 for convenience.

Table 5.5. ARB/US EPA Off-Road Compression Ignition Engine Standards for NOx.

Maximum Rated Horsepower (hp)	Model Year	NOx	NOx+NMHC
100≤hp<175	2000-2002	6.9	
	2003-2006	—	4.9
	2007 and later	—	3.0
175≤hp<300	2000-2002	6.9	
	2003-2005	—	4.9
	2006 and later	—	3.0
300≤hp<600	2000	6.9	
	2001-2005		4.8
	2006 and later		3.0
600≤hp≤750	2000-2001	6.9	
	2002-2005		4.8
	2006 and later		3.0
hp>750	2000-2005	6.9	
	2006 and later		4.8

Again, for the purpose of calculating NOx emissions for CMP evaluation, assume that NOx comprises 95% of the combine NMHC+NOx emissions.

South Coast District Credit Generation Rules

On May 11, 2001, the South Coast District adopted four rules designed to generate NOx emission reduction credits for its Regional Clean Air Incentives Market (RECLAIM) program. Two of these rules (Rules 1631 and 1632) apply to marine vessels. Rule 1631-- *Pilot Credit Generation Program for Marine Vessels* – allows for the generation of NOx credits through the voluntary replacement of harbor craft diesel engines with new cleaner engines. Several vessel owners have participated in the program. Rule 1631 was recently amended to allow for the inclusion of re-manufactured engines as well as new engines. Under Rule 1632 -- *Pilot Credit Generation Program for Hotelling Operations* -- NOx credits can be generated when vessels near ports use electrical power supplied by fuel cells. To date, credits have not been generated under Rule 1632. Actions that receive NOx credits for these South Coast District programs are not eligible for CMP funding.

Proposed ARB Strategies
ARB is proposing the four measures listed in Table 5.6 for the "Commercial Marine Vessels and Ports" component of the *South Coast State Implementation Plan*. Three of these measures control emissions from marine vessels, while the third applies to land-side port sources. Each includes different regulatory options that will be evaluated and/or pursued. Combined, the three measures are expected to achieve significant reductions in NOx, PM10, and ROG. The first two measures will undoubtedly affect CMP marine applicants.

Table 5.6. Proposed Strategies for Commercial Marine Vessels and Ports

Strategies	**Timeframe**	
	Action	**Implementation**
MARINE-1: Set More Stringent Emission Standards for New Harbor Craft and Ocean - Going Ships	2003 – 2004	2008 – 2010
MARINE-2: Pursue Approaches to Clean Up the Existing Harbor Craft Fleet - Cleaner Engines and Fuels	2003 – 2005	2005
MARINE-3: Pursue Approaches to Clean Up the Existing Ocean-Going Ship Fleet	2003 – 2005	2005 - 2010
MARINE-4: Pursue Approaches to Reduce Land-Based Emissions at Ports	2003 – 2005	2003 - 2010

All of the emission standards and emission reduction strategies described above will directly impact the NOx reduction benefits of new engine purchases, after the their effective date of implementation. The total NOx reduction eligible for CMP funding is that portion of the reduction in excess of what would be achieved through the new standards or policies. In order to provide engine manufacturers an incentive to produce engines that are cleaner than those required by regulations, the federal government developed the "Blue Sky Series Program."

Table 5.7. "Blue Sky Series" Voluntary Emission Standards.

Cylinder Displacement (D, dm^3)	**NOx+THC, g/kWh**	**PM, g/kWh**
Power ≥ 37 kW & D < 0.9	4.0	0.24
0.9 ≤ D < 1.2	4.0	0.18
1.2 ≤ D < 2.5	4.0	0.12
2.5 ≤ D < 5.0	5.0	0.12
5.0 ≤ D <15	5.0	0.16
15 ≤ D < 20 & Power < 3300 kW	5.2	0.30
15 ≤ D < 20 & Power < 3300 kW	5.9	0.30
20 ≤ D < 25	5.9	0.30
25 ≤ D < 30	6.6	0.30

Blue Sky Series Program

The Blue Sky Series program permits manufacturers to certify their engines to more stringent emission standards than required. The qualifying emission limits are listed in Table 5.7. Marine engines that meet the Blue Sky Series standards are excellent candidates for participation in the CMP.

MARINE EMISSION CONTROL TECHNOLOGIES

Marine NO_X emissions can be reduced through methods that affect the engine process directly or by using equipment that is not integrally part of the engine but rather "added on" (i.e., retrofits) to manage emissions post-combustion. The former, namely engine optimization modifications, are evolving through land-based engines in response to tightening on-road and off-road regulatory controls. Marine engines are expected to incorporate many of these improvements, which include basic redesign of the combustion chambers, retarding the timing, improving high-pressure fuel injection systems, upgrading or adding aftercooling and turbocharging, injecting water into the air intake using humid air motors (HAM), and exhaust gas recirculation (EGR). Natural gas engines, which offer significant emission benefits over diesel engines, have also entered the marine engine market with growing support. The benefits of these technology improvements will be reflected through the certification of new engines with lower emission rates.

Typical projects that would qualify for incentive funding under the CMP for marine vessels would include the use of retrofit kits or repowers to lower NOx emissions, or the purchase of new reduced-NOx marine engines. Natural gas engines are also eligible for CMP funding. Other projects, such as "cold ironing " may also be eligible. These types of projects will be evaluated on a case-by-case basis by the ARB and participating district. Projects where gasoline-fueled engines are replaced with new diesel engines or diesel engines are replaced with gasoline engines are not eligible for the CMP.

There are also a number of emerging retrofit technologies available or soon to be available for marine engines. However, most of these technologies, such as catalyst-based diesel particulate filters (CB-DPF) and oxidation catalyst (OC), although good for controlling other pollutants, are ineffective at reducing NOx from diesel engines. One important exception is selective catalytic reduction (SCR) – a technology currently used on several marine vessels worldwide.

SCR uses ammonia or urea as a reducing agent for NO_X over a catalyst composed of precious metals. Using SCR technology, NO_X reductions of 98% have been reported at high engine loads [MECA, 1999; US EPA, 1999]. While SCR does not increase fuel consumption and can be installed on engine systems using high-sulfur residual fuel, the technology involves the consumption of ammonia or urea at a rate equal to about 2% of the fuel consumption. Current-technology SCR units also take up considerable space, add significant weight to ships and require regular maintenance (addition of the regent). They are expensive and their effectiveness decreases significantly at reduced temperatures exhibited during partial engine loads. Studies show that NOx emission reductions are reduced to about 57% at partial loads [MECA, 1999; US EPA, 1999].

SCR is eligible for CMP funding. Assuming the SCR is 90% effective at full load and 50% effective at partial loads. ARB assumes an overall effectiveness of 78% NOx reduction for SCR technology (based on the E3 duty cycle, which implies that 70% of the time is spent at engine loads greater than or equal to 75%). For CMP purposes, it is assumed that this level of effectiveness is maintained over the life of the engine.

BASELINE NOx EMISSIONS

The number of engines used, their size, type, and power rating along with operational parameters, maintenance practices and the marinization process are all determinants of a marine vessel's NOx output. For the purpose of calculating NOx reductions, propulsion engine baseline emission factors should be based on in-situ test data. The applicant must submit a detailed written explanation of the procedure to the district and ARB for approval. The duty cycle of preference is based on the ISO 8178 test cycles discussed below. If in-situ testing is not feasible, the applicant can use the default baseline emission factors provided in Table 5.8 for propulsion engines. Certification emission factors can serve as baseline emission rates for auxiliary engines.

The emission factors in Table 5.8 are currently being updated using actual in-situ test data from the districts. Ultimately, emission factors for marine engines will be developed and integrated into ARB's emission inventory models. At such time, participating districts will be notified by ARB of the updates necessary for Table 5.8. Because of the high variability in marine engine emission rates, ARB encourages districts to require in-situ testing following approved test procedures. The default in-use emission factors in Table 5.8 are conservative to encourage testing. When in-situ testing is conducted in accordance with approved procedures, those results must be used when calculating NOx reductions. The maximum acceptable value of a baseline emission factor derived from in-situ source testing is 20 g/bhp-hr.

Table 5.8. Harbor Vessel NOx Emission Factors (g/bhp-hr).

Emissions Configuration	2 Stroke[a] Naturally-Aspirated (g/bhp-hr)	2 Stroke[a] Turbocharged (g/bhp-hr)	4 Stroke[b] Naturally-Aspirated (g/bhp-hr)	4 Stroke Turbocharged[b], Turbocharged/ Aftercooled (g/bhp-hr)
Pre 1980 Engines	14[c]	11	8	7
Post 1980 Engines	8	7	7	6

[a]2 Stroke = Typically DDC-53 or –71 series
[b]4 Stroke = Cat/Cummins and others
[c]The 14 g/bhp-hr baseline is listed for EMD engines used in marine applications

Test Cycles for In-Situ Testing

A single emission test cycle or procedure can not appropriately capture the emission differences among various engine types and operating behavior. Recognizing this, the ISO has developed a number of test cycles that more accurately represent marine engine performance in a non-homogeneous fleet. The ARB requires the following duty cycle/engine match for in-situ testing.

Constant speed propulsion engines are to be tested on the ISO 8178- E2 test cycle and constant speed auxiliary engines on the ISO 8178-D2 test cycle. Variable speed auxiliary engines and variable speed propulsion engines used with variable-pitch propellers (or electrically coupled propellers) will be tested on the ISO 8178-C1 duty cycle. All other Category1 and 2 engines, including those used with fixed-pitch propellers, will be tested on the ISO 8178-E3 Marine Propeller Law Heavy Duty operating cycle.

There are several portable sampling systems on the market that can give accurate results. Engine speed can be monitored directly, but load may have to be determined indirectly. For constant speed engines, it is straightforward to set the engine to the points specified in the duty cycles. All engines should be tested using the diesel fuel type most commonly used in actual operation. The fuel type used by California commercial harbor craft -- marine distillate fuel (MDA) – is basically the same as on-road diesel. In fact, nearly all MDA is simply re-branded fuel originally manufactured for on-road use. Absent marine fuel standards, this will likely continue to be the case when new on-road diesel fuel standards go into effect in 2006. Refiners are not likely to develop a different fuel for the marine sector, which is roughly 6% of the diesel fuel market [U.S. EPA, 1999].

Because new commercial marine engines are likely to meet Tier 2 NOx standards without the use of sophisticated emission control devices (e.g., oxidation catalyst), the use of higher sulfur fuel will not likely have a significant impact on NOx emissions. For the same reason, ARB assumes (for the purpose of CMP funding) that the NOx emission differential between the existing engine and the replacement engine is maintained over the life of the replacement engine. We assume that maintenance practices generally do not change and that wear and deterioration of the new engine does not significantly increase NOx emissions relative to the replaced engine.

PROJECT CRITERIA

The following requirements and selection criteria for CMP marine applications are intended provide guidance for evaluating projects. Project selection should emphasize total emission reductions, cost effectiveness, and project implementation timeframe. Eligible marine vessel projects include new and used replacement engines as well as retrofitted engines. Funding is available for Category 1, 2, and 3 engines. However, previous experience dictates that Category 1 and 2 engines are the most likely projects. To date, marine vessel projects funded under the CMP have almost exclusively been engine replacements. Older, more-polluting diesel engines have been replaced with cleaner diesel engines -- the majority on fishing vessels and tugboats. Engine replacement projects will, most likely, comprise the majority of requests for CMP funding.

Qualifying marine applications for CMP funding must meet the following minimum requirements:

- NOx emission reductions must be beyond what is required by any district rule and all state, national and international regulations including all existing and forthcoming applicable regulations for propulsion and auxiliary engines. This includes, but is not limited to, the IMO Annex VI standards (retro-active to 2000 if ratified), the U.S.EPA diesel marine standards, ARB off-road diesel standards (for auxiliary engines) and any forthcoming ARB standards or regulations.

- NOx reductions must not result in increases in PM or HC emissions relative to baseline levels.

- A marine project receiving any type of credit or funding for emission reductions is ineligible for CMP funding. For example, if an engine replacement generates any type of emission credit such as a Mobile Source Emission Reduction Credit (MSERC) or is used in part or wholly to fulfill obligations for another program such as Rules 1631 and 1632, it is not eligible for CMP funding.

- The replacement engine or retrofit must provide a 15% minimum NOx improvement relative to the baseline engine. A 30% reduction is required for new engine purchases. Use of certification emission factors for new replacement engines and in-situ source test data for replacement engines and the baseline engine (although the default values in Table 5.8 can be used). If the replacement engine is significantly modified or re-configured in anyway during its life, in-situ testing must be conducted to determine its new emission rates.

- When using fuel consumption to calculate emission reductions, the change in energy horsepower must be taken into account. When the horsepower rating of the new engine is at least 25% greater than the rating of the replaced engine, multiply the calculated emissions reduction by the following factor:

  $$\text{Modified Emissions} = E_r * \frac{\text{Rating of old engine}}{\text{Rating of new engine}}$$

  where, E_r = the emissions difference between existing and replacement engine

- Marine vessels employing “wet” exhaust technology -- where emissions are exhausted directly into the water – are not eligible for CMP funding. The ARB is not aware of a repeatable test procedure for measuring “wet” emissions.

- The marine vessel applying for CMP funds must operate entirely in California waters. California water boundaries are defined by the districts as emission inventory boundaries. If a local district has not established an emission inventory boundary, the applicant is to use a default value of 10 miles offshore.

- Non-captive California fleets may be considered on case-by-case basis for funding if their operation in California coastal waters can be properly documented.

- The cost effectiveness must not exceed $13,600 per ton of NOx reduced (see calculation explanation below).

- Reduced emission levels must be maintained for a minimum of 5 years.

- The acceptable project life, which is the average engine life reported by U.S.EPA, for calculating emission benefits from marine vessels are as follows:

	Project Life
Category 1 engines	16 years
Category 2 engines	23 years
Auxiliary engines (categories 1 & 2)	17 years

Based on information from manufacturers, the U.S.EPA estimates Category 1 engines to last 16 years, with two rebuilds occurring at the end of the fifth and tenth years (U.S.EPA, 1999). Similarly, they assume category 2 engines to last 23 years with three rebuilds occurring after years six, twelve, and eighteen. Auxiliary engines used in marine applications last approximately 17 years (U.S.EPA, 1999). A life-span different than those listed above can be used if it is adequately supported with documentation.

The above project requirements and selection criteria are constantly undergoing review at ARB as new data and information becomes available. Consequently, these requirements and selection criteria (i.e., baseline emission factors) are subject to updates. The ARB will notify the Districts of changes and updates in order to improve project selection or prioritization. All CMP funding for marine applications for ocean-going vessels will be decided on a case-by-case basis by ARB and district staff.

EMISSION REDUCTION CALCULATIONS

Air quality benefits of new or retrofitted marine vessel engines are based on emission factors (EF). When calculating emission reductions, annual engine operating time is multiplied by the product of the brake specific NOx emission factor and the rated engine power for the new or newer replacement engine minus the product of the NOx emission factor and the rated engine power for the existing engine. Results are then converted to tons per year.

Annual NOx Reductions = Annual hours of operation * [(Baseline NOx EF * Baseline Rated Power) – (New NOx EF * New Rated Power)] * (tons/year) * ton/907200 g

Annual Hours of Operation = Estimated annual hours of engine operation for the existing engine to be replaced or altered (hours/year)

Baseline NOx EF = NOx emission factor for exising engine (g/bhp-hr)

New NOx EF = NOx emission factor of the replacement engine (new, rebuilt, or retrofit) (grams/bhp-hr)

Baseline Rated Power = Power rating of existing engine (hp)

New Rated Power = Power rating of the replacement engine (hp)

Conversion Factor = 907,200 grams/ton

<u>Alternative Emission Calculation Method Using Fuel Consumption</u>
In order to calculate the total annual emission output, the emission factors (those in Table 5.8 or obtained through in-situ testing) must be multiplied by the amount of time the engine is operated. Recognizing that not all vessel operators maintain records of engine operating time, we provide an alternative calculation method based on fuel consumption. If the annual hours of engine operation are not known but annual fuel consumption for the engine is known, the applicant can multiply the difference in emission factors (old vs. new) by the appropriate fuel consumption factors listed in Table 5.9. The product is then multiplied by the number of gallons consumed annually to get the total annual emissions which is then converted to tons/year.

Table 5.9: Fuel Consumption Rate Factors.

Engine	Fuel Consumption Rate
Category 1	18.5 bhp-hr/gal
Category 2	20.8 bhp-hr/gal

For example, if a 1970 two-stroke category 1 naturally aspirated engine uses 20,000 gallons/year. This is being compared to a new engine that emits at a rate of 7 g/bhp-hr, the annual NOx emission reduction could be calculated as:

*20,000 gal/yr * (14.0 g/bhp-hr-7g/bhp-hr) * 18.5 bhp-hr/gal * ton/907,200 g = 2.85 tons/year*

<u>Cost-Effectiveness Calculations</u>
Project cost-effectiveness is based on the incremental capital cost, the expected life of the project, the interest rate, and the estimated annual NOx reductions. All calculations will use a three percent (3%) discount rate to reflect the opportunity cost of public funds for the CMP. Incremental costs are determined by taking the cost differential between the capital cost of the chosen project (e.g., the new engine or retrofit cost) and the cost of the alternative course of action (e.g., the replacement dirtier engine that was not purchased or the engine rebuilt that was foregone). Incremental costs are multiplied by a capital recovery factor and divided by the annual NOx reductions. This calculation will result in annualized project cost-effectiveness.

Project Incremental Capital Cost =
Chosen Project Capital Cost – Alternative Project Capital Cost

Chosen Project Capital Cost = capital costs of chosen project (e.g., new engine with low NOx emissions)

Alternative Project Capital Cost = costs of alternative action (e.g., a new engine with higher NOx emissions)

Capital Recovery Factor = $[(1 + i)^n (i)]/[(1 + i)^n – 1]$

Where i = discount rate (3%)
n = project life

Annualized Cost = Incremental Project Capital Cost * Capital Recovery Factor

Cost-Effectiveness = Annualized Cost / Annual NOx Reductions

Example 1
Propulsion Engine Purchase
Consider an owner faced with the opportunity to purchase a tugboat equipped with a Category 1 engine in the year 2004. The marine owner applies for funding to purchase the tugboat with a "Blue Sky" certified 800 hp diesel engine that cost $250,000. The Blue Sky engine has a certified THC+NOx emission factor of 5.0 g/bhp-hr. In lieu of purchasing this engine, the owner could purchase a 700 hp engine for $200,000 that just meets the Tier 2 THC+NOx standard of 7.2 g/bhp-hr. The owner operates the engine for 900 hours per year.

<u>Emission Reduction Calculation</u>

Baseline NOx EF	=6.84 g/bhp-hr (NOx = 95% of the 7.2 g/bhp-hr HC+NOx EF)
New NOx EF	=4.75 g/bhp-hr (NOx = 95% of the 5.0 g/bhp-hr HC+NOx EF)
Baseline Rated Power	=700 hp
New Rated Power	=800 hp
Annual Hours of Operation	=900 hours

Estimated NOx reductions are:

900 hours/yr * [(6.84 g/bhp-hr * 700 hp) – (4.75 g/bhp-hr * 800 hp)] * ton/907200 g = **0.98 tons/year**

- Cost Effectiveness Calculation

Chosen Project Capital Cost	(Purchased Engine)	$ 250,000
Alternative Project Capital Cost	(Engine not purchased)	$ 200,000
Project Life	(Category 1 engine)	16 years

Incremental Project Cost:	$ 250,000 - $ 200,000 = $50,000
Capital Recovery Factor:	$[(1 + 0.03)^{16} (0.03)]/[(1 + 0.03)^{16} - 1] = 0.0796$
Annualized Cost:	$ 50,000 * (0.0796) = $ 3,980/ year
Cost Effectiveness:	($ 3,980 / year) / (0.98 tons/year) = **$3,901/ ton**

The cost of NOx reduction in this example is less than $13,600 per ton. Therefore, this project is eligible for CMP funds.

Example 2
Tugboat Engine Replacement

Consider an owner faced with the opportunity to replace a tugboat engine during the normal engine overhaul period. In this case, the marine owner applies for funding to replace a 1,400 hp tugboat engine with a new 20,00 hp category 1 diesel engine. The new engine emits NOx at the rate of 6.8 g/bhp-hr. Based on in-situ testing, it was found that the old engine emits at a rate of 10.8 g/bhp-hr. The cost for rebuilding the old 1,400 hp engine is $100,000. The new engine is priced at $250,000. The marine vessel owner also documents that the annual fuel consumption for this tugboat in California would be approximately 90,000 gallons.

<u>Emission Reduction Calculation</u>

Annual Fuel Consumption:	90,000 gals/year
Fuel Consumption Rate	18.5 bhp-hr/gal
Reduced NOx Emission Rate	6.8 g/bhp-hr
Existing NOx Emission Rate	10.8 g/bhp-hr
Old Horsepower	1400 hp
New Horsepower	2000 hp

Estimated NOx reductions are:

90,000 gals/year * [(10.8 g/bhp-hr –6.8 g/bhp-hr)*(1400/2000)]* 18.5 bhp-hr/gal * ton/907,200 g = **5.14 tons/year**

<u>Cost Effectiveness Calculation</u>

Rebuild cost	$100,000
Capital cost of new engine	$250,000
Project life	16 years

Incremental Project Cost:	$ 250,000 - $ 100,000 = $150,000
Capital Recovery Factor:	$[(1 + 0.03)^{16} (0.03)]/[(1 + 0.03)^{16} - 1] = 0.0796$
Annualized Cost:	($150,000) * (0.0796) = $11,940 / year
Cost Effectiveness:	($11,940/ year) / (5.14tons/year) = **$61,372/ton**

The cost benefit for the example is greater than $13,600 per ton of NOx reduced. This project does not qualify for grant funds.

Example 3
Auxiliary Engine Repower

Consider this same owner also wants to replace one auxiliary engine rated at 92 hp that operates 900 hours/year. The existing engine emits at a rate of 8.0 g/bhp-hr. The new engine is also rated at 92 hp, but has an NOx + NMHC emission rate of 4.9 g/bhp-hr. The capital cost for rebuilding the auxiliary engine is $2,000 and the replacement engine costs $15,000, based on supporting documentation.

Emission Reduction

Baseline NOx EF	=8.0 g/bhp-hr
New NOx EF	=4.66 g/bhp-hr (NOx = 95% of the 4.9 g/bhp-hr NMHC+NOx EF)
Baseline Rated Power	=92 hp
New Rated Power	=92 hp
Annual Hours of Operation	=900 hours

Estimated NOx reductions are:

900 hours/yr * [(8.0 g/bhp-hr * 92hp) – (4.66 g/bhp-hr * 92 hp)] * ton/ 907200 g = **0.30 tons/year**

Cost Effectiveness Calculation

Incremental Project Cost:	$ 15,000 - $ 2,000 = $ 13,000
Project Life (auxiliary engine)	17 years
Capital Recovery Factor:	$[(1 + 0.03)^{17} (0.03)]/[(1 + 0.03)^{17} - 1] = 0.076$
Annualized Cost:	$ 13,000 * 0.076 = $ 987/ year
Cost Effectiveness:	($ 987 / year) / (0.30 tons/year)= **$296/ton**

The cost benefit for the example is less than $13,600 per ton of NOx reduced. This project qualifies for grant funds.

Reporting and Monitoring

The district and ARB have the authority to conduct periodic checks or solicit operating records from the applicant that has received CMP funds for each retrofitted or replaced marine engine. This is to ensure that the engine is operated as stated in the project application. Hence, the applicant must maintain operating records and have them available upon request by ARB or the district. Records must contain, at minimum: marine vessel identification numbers; retrofit hardware model and serial numbers; nautical miles traveled in the district and California coastal waters; estimated fuel consumption in California coastal waters; estimated hours of operation in the California coastal waters; hours in idle; and maintenance and repair dates (or any servicing information). Records must be retained and updated throughout the project life and made available for inspection.

Sample Project Application

In order to qualify for incentive funds, districts provide project applications and solicit bids for reduced-emission projects from marine vessel owners. A sample application has been provided in the appendix. The applicant must provide the type of information illustrated below in Table 5.10.

Table 5.10. Suggested Information Required To Evaluate Marine Vessel Project.

1. Air District:
2. Applicant Demographics
   - Company Name:
   - Business Type:
   - Mailing Address:
   - Location Address:
   - Contact Number:
3. Project Description
   - Project Name:
   - Vessel Type: (passenger ship, ferry, fishing boat, tug boat, etc.)
   - Propulsion Type:(motorship or steamship)
   - Engine Function:
   - Ship Service Speed:
   - Ship Deadweight Tonnage (DWT):
4. Avg. fuel consumption (gallons) per port call for each service mode
   - Cruise:
   - P-zone Cruise:
   - Maneuvering:
   - Hotelling:
5. Annual number of Port Calls in California:
6. Avg. time (hours) per port call in each service mode, and fuel consumption rate
   - Cruise:
   - P-zone Cruise:
   - Maneuvering:
   - Hotelling:
7. Ave. fuel consumption (gallons) per port call for Auxiliary Power
   - a) Boilers (motorship)
   - b) Engines (motorship)
   - c) Main boilers (steamship)
8. Application: (Repower, Retrofit or New)
9. Percent Operated within districts emission inventory:
10. Project Life (years):
11. Average Nautical Miles per port call within California coastal water boundary:
12. Old Engine Information
    - Horsepower Rating:
    - Engine Make:
    - Engine Model:
    - Engine Year:
13. New Engine Information
    - Horsepower Rating:
    - Engine Make:
    - Engine Model:
    - Engine Year:
    - Fuel Type:
14. NOX Emissions Reductions
    - Baseline NOx Emissions Factor (g/bhp-hr):
    - NOx Conversion Factors Used:
    - Reduced NOx Emissions Factor (g/bhp-hr):
    - Estimated Annual NOx Emissions Reductions:
    - Estimated Lifetime NOx Emissions Reductions:
15. Cost ($) of the Base Engine
16. Cost ($) of Certified LEV Engine:
17. PM Emissions Reductions
    - Baseline PM Emissions Factor (g/bhp-hr):
    - PM Conversion Factors Used:
    - Reduced PM Emissions Factor (g/bhp-hr):
    - Estimated Annual PM Emissions Reductions:
    - Estimated Lifetime PM Emissions Reductions:
18. District Incentive Grant Requested:

Chapter Six
STATIONARY AGRICULTURAL IRRIGATION PUMP ENGINES

This chapter presents the project criteria under the CMP for stationary agricultural irrigation pump engines. It also contains a brief overview of NOx emission inventory, current emission standards, available control technology, potential projects eligible for funding, and emission reduction and cost-effectiveness incentive methodologies.

EMISSION INVENTORY

Stationary IC engines used for agricultural purposes in California are widely utilized to power irrigation water pumps. For the purposes of the CMP, these engines can be considered part of the off-road engine inventory because off-road engines are often utilized in these applications. However, due to the operating characteristics specific to stationary agricultural irrigation pump engines, they are evaluated separately from the off-road equipment category. The CMP will continue to provide funds for agricultural pump engines rated at 50 hp or greater for the voluntary reduction of NOx emissions.

Agricultural irrigation pumps are powered electrically and with IC engines. However, the actual number of agricultural pump engines in use is a matter of debate. A 1995 report by Sonoma Technology, Inc. for the SJVAPCD indicates a high percent of irrigation pumps in the San Joaquin Valley are electrically powered. However, SJVAPCD has observed recently that a small percentage of the irrigation pumps are electric. The remaining pumps are engine-driven and fueled most commonly with diesel and, to a lesser degree, with natural gas or propane. In the San Joaquin Valley, the SJVAPCD has replaced approximately 2500 diesel agricultural pumps through their Heavy-Duty Engine Incentive Program since 1997. Diesel is most commonly used due to its lower cost and the limitations posed by inaccessibility to natural gas lines in certain rural areas. In general, stationary agricultural irrigation pump engines run an average of 10,000 hours before requiring an overhaul or rebuild. This equates to a variety of engine lifetimes depending on each engine owner's operating schedule and maintenance routine. Stationary agricultural irrigation pump engines generally have low annual operating hours, from 1,000 to 3,600 hours per year. Using this range, an engine can run 3 to 10 years before rebuild. If an engine can be rebuilt 3 to 4 times, 30 to 40 years of engine life are possible. Once an engine has exhausted its useful life, the most common engine replacement practice is the purchase of a rebuilt engine rather than a new engine.

Stationary agricultural irrigation pump engines can be considered a seasonal source of NOx emissions. Although NOx emissions occur throughout the calendar year, most NOx emissions occur throughout the spring and summer months during the primary crop growing period. According to the ARB's 1997 baseline NOx emission inventory for agricultural irrigation pumps powered by diesel engines, average NOx emissions are 34 tons per day. However, seasonal NOx emissions may be as high as 52 tons per day in the summer months from increase usage throughout the San Joaquin Valley [Sonoma Technology 1995]. This seasonal variation is critical because the potential higher emissions occur on high temperature (i.e., high ozone) days. ARB's estimated NOx emissions are based on data provided by San Joaquin Valley and Santa Barbara County Air Pollution Control Districts. Future emissions are projected to remain approximately the same through 2010.

EMISSION STANDARDS

Historically, local districts have not regulated emissions from stationary agricultural engines. District prohibitory rules for stationary IC engines specifically exempt agricultural engines from the requirements of district rules. Therefore, stationary agricultural engine emissions are largely uncontrolled, except in cases where engines 1996 model year and newer are in use. These engines are subject to ARB/U.S.EPA off-road diesel engine emission standards.

In January 1992, ARB adopted exhaust emission standards for 1996 and later model year off-road diesel cycle engines ≥175 hp. The U.S.EPA has adopted similar NOx emission standards for new off-road diesel cycle engines; however, the U.S.EPA standards apply to off-road engines ≥50 hp. Table 6.1 below lists both the ARB and U.S.EPA standards. The combination of ARB and U.S.EPA emission standards means that all of today's new off-road diesel cycle engines greater than 100 hp and smaller than 750 hp have to be certified to meet Tier 2 NOx+NMHC emission standards of 4.9 or 4.8 g/bhp-hr, depending on size. Starting in January 1, 2004, the Tier 2 requirements extend to engines in the less than 100hp size range.

CONTROL STRATEGIES

Commercially available control technologies for stationary agricultural engine projects exist in the marketplace.

Emission-Certified Engines

A viable and cost-effective way to reduce emissions from uncontrolled diesel engines is to replace the engine (i.e., repower) with an emission-certified off-road CI or SI engine instead of rebuilding the existing engine to its original uncontrolled specifications. Emission-certified diesel engines are currently commercially available for off-road engines ≥ 50 hp. The appropriate engine size for an irrigation pump will depend on factors such as water demand and size of the irrigation pump. ARB adopted exhaust emission standards for new large, off-road spark-ignition (LSI) engines on October 22, 1998 with implementation beginning in 2001. The emission standards are applicable to non-preempted off-road SI engines > 25 hp. For the CMP, eligible off-road SI engines are required, at a minimum, to meet the off-road diesel emission standards for the applicable model year and horsepower rating. Thus, repowers with off-road SI engines must undergo applicable certification testing to verify emission levels.

Electric Motors

Another potentially cost-effective strategy to reduce emissions significantly from uncontrolled engines is to replace an existing IC engine with an electric motor instead of rebuilding the engine to its original uncontrolled specifications. Replacement of an older electric motor for a newer electric motor on an agricultural irrigation pump does offer emission reduction benefits. Irrigation pumps powered by electric motors are commercially available for various applications. Hence, the requirements for electrification projects under the CMP are retained and continue to target the replacement of IC engines used in agricultural irrigation pumps. The viability of an electrification project depends on a number of factors, including cost of electricity and proximity to an electric power grid.

Table 6.1. ARB and U.S.EPA Exhaust Emission Standards for New Off-Road Diesel Engines > 50 hp.

(g/bhp-hr)							
Maximum Rated Power (hp)	Tier	Model Year	NOx	HC	NOx+NMHC	CO	PM
50-<100	Tier 1	2000-2003	6.9	—	—	—	—
	Tier 2	2004-2007	—	—	5.6	3.7	.3
	Tier 3	2008 and later	—	—	3.5	3.7	—
100-<175	Tier 1	2000-2002	6.9	—	—	—	—
	Tier 2	2003-2006	—	—	4.9	3.7	.22
	Tier 3	2007 and later	—	—	3.0	3.7	—
175-<300	Tier 1	1996-2002	6.9	1.0	—	11.4	0.54
	Tier 2	2003-2005	—	—	4.9	2.6	.15
	Tier 3	2006 and later	—	—	3.0	2.6	—
300-<600	Tier 1	1996-2000	6.9	1.0	—	8.5	.40
	Tier 2	2001-2005	—	—	4.8	2.6	.15
	Tier 3	2006 and later	—	—	3.0	2.6	—
600-<750	Tier 1	1996-2001	6.9	1.0	—	8.5	.40
	Tier 2	2002-2005	—	—	4.8	2.6	.15
	Tier 3	2006 and later	—	—	3.0	2.6	—
>750	Tier 1	2000-2005	6.9	1.0	—	8.5	.4
	Tier 2	2006 and later	—	—	4.8	2.6	.15

Engine Retrofit Technology

Any retrofit technology must be verified by ARB before it can be sold in California, must be able to reduce NOx emissions by at least 15%, and must comply with established durability and warranty requirements. There may be some retrofit technologies available for pre-1996 model year off-road diesel engines that can reduce NOx emissions from uncontrolled levels. ARB has certified diesel engine retrofit kits for select Detroit Diesel Corporation pre-1993 model year engines. The retrofit technology is certified to a NOx emission standard no greater than 5.8 g/bhp-hr. Currently, retrofit kits are available for a limited number of engine models, some of which may be engines in the size range typically used for agricultural irrigation pumps. It is also possible that retrofit technologies that have been used to reduce NOx and PM emissions from on-road and off-road diesel engines may be applied to reduce engine emissions in some agricultural pump applications.

Auxiliary Engine Technologies for Reduced Emission Stabilization

Recent in-field testing, spot checks, and follow-up annual tests conducted by the Santa Barbara APCD revealed significant variation in NOx levels over time relative to initial setup conditions on some alternative fuel (natural gas/propane) stationary agricultural water pump engines funded by the CMP. Because of varying operating conditions for these engines, NOx conversion can drop dramatically at lean fuel mixtures. Auxiliary engine technologies such as closed-loop air to fuel ratio controllers (AFC) are currently available to help maintain low emission levels over the engine project life. ARB requires that non-certified alternative fuel off-road agricultural engines be outfitted with 3-way catalytic converters, but no requirement exists for any type of auxiliary control such as AFC's.

In practice, three-way catalysts are used with AFCs to give satisfactory catalyst operation for efficient NOx control. However, agricultural engines are exempt from permits and AFC's are uncommon for farming operations. Auxiliary engine technology such as AFC's establish efficient NOx control year-round, save fuel, extend catalyst life, and compensate for natural gas fuel quality (i.e., higher-than-normal BTU natural gas or hot gas). For these reasons, ARB and local districts will evaluate on a case-by-case basis the possible benefits offered by requiring that alternative fuel engines be equipped with a closed-loop AFC and 3-way catalytic converter, as proposed by the engine manufacturer/vendor/grantee. Additional hardware requirements for natural gas or propane engines for which this technology can be applied (AFC + 3-way catalyst) ensure that emission reductions paid for by program funds are fully realized. For engines funded in the past by the CMP and equipped with 3-way catalyst only (no AFC), ARB will encourage air districts to consider the option of retrofitting these engines with an appropriate AFC if recommended by the engine manufacturer/vendor. The cost for AFC retrofit may be funded, if applicable, from the air district's matching funds.

PROJECT CRITERIA

The project criteria below have been designed to provide districts and potential applicants with a list of minimum eligibility requirements for CMP funding. Criteria continue to focus on emission reductions, cost-effectiveness, and the ability for a project to be completed within the timeframe of the program. Reduced-NOx stationary agricultural irrigation engine projects that include replacement of an existing engine (new engine purchase, repowers, replacement with electric motors) or existing engine retrofits can be considered for the CMP.

Criteria for any diesel-to-diesel repower projects requires that the replacement engine meet current standards, which presently means Tier 2 standards for engines in the 100 hp to 750 hp range. Uncontrolled engines (pre-1996 model year $\geq$50 hp) can also be repowered with new or rebuilt off-road SI engines that test at a NOx level that meets the current diesel standard or new electric motors. Retrofit kits that are verified to the off-road emission standard for use on pre-1996 model year off-road engines are also eligible. For 1996 and later model year engines, the repowered unit may also be an engine certified to the off-road credit standards (for either diesel or SI engines) or an electric motor. Retrofit kits for 1996 and later model year engines must be verified to reduce NOx emissions by at least 15%. The project criteria include requirements that all engines be tested using approved ARB test procedures. Eligibility criteria are as follows:

- An engine must be rated at 50 hp or greater, which is equivalent to an electric motor 37 kilowatts or greater.

- A new purchase of a 2003 or later model year agricultural irrigation pump must have an electric motor.

- A repower of an uncontrolled (pre-1996 model year) engine must be with:
  1) A new or OEM-rebuilt off-road diesel engine certified to the current applicable NOx+NMHC emission standard shown in Table 6.1. At present, for off-road engines rated between 100 hp and 750hp, the current emissions standard is Tier 2.
  2) A new or OEM-rebuilt off-road SI engine tested to meet the current off-road NOx diesel engine standard shown in Table 6.1.
  3) A new electric motor.

- A retrofit of an uncontrolled (pre-1996 model year) engine must be with a retrofit kit that is verified to reduce NOx emissions to at least 6.9 g/bhp-hr.

- A repower of an emission-certified (1996+ model year) off-road engine must be with:
  1) A new or OEM-rebuilt off-road diesel engine certified to the current applicable NOx+NMHC emission standard shown in Table 6.1. At present, for off-road engines rated between 100 hp and 750hp, the current emissions standard is Tier 2.
  2) A new or OEM-rebuilt off-road diesel engine certified to one of the applicable NOx emission credit standards listed in Table 6.2.
  3) A new or OEM-rebuilt off-road SI engine tested to meet the off-road NOx emission credit standards.
  4) A new electric motor.

- A retrofit of an emission-certified (1996+ model year) off-road engine must be with a retrofit kit that is verified to reduce NOx emissions by at least 15%.

- Eligible rebuilt or remanufactured engines must be emission-certified, use only OEM components, and be procured from the OEM or its authorized dealers/distributors.

- If applicable, NOx emission levels shall be determined by multiplying 0.95 to the certified NOx+NMHC emission standard for diesel engines and by 0.80 for alternative fuel engines.

- Engines must be tested using ARB test procedures for off-road engines.

- The maximum project life when determining project benefits is as follows:

	Default without Documentation	Default with Documentation
New purchase/ Repower	7 years	10 years

A different project life may be selected for approval by ARB staff. However sufficient documentation must be provided to ARB that supports the selected project life based on the actual remaining useful life.

- Emission-certified engines model year 1996 and can be certified to one of the applicable NOx emission credit standards listed in Table 6.2

Table 6.2. NOx emission credit standards.

Engine Model Year	Engine Horsepower Rating (bhp)	Qualifying NOx+NMHC Level (g/bhp-hr)
1996-2000	50-750	4.5
2000+	750+	4.5
2001+	50-750	4.0

- Electric motors must only replace IC engines that are fueled with diesel and the applicant must have documentation of payment to the local utility company for power installation. This requirement of documentation also applies to new installations.

- Reduced-emission engines or retrofit kits must be certified for sale in California and must comply with durability and warranty requirements. Qualified engines include new ARB-certified engines or ARB-certified aftermarket part engine/control devices.

- NOx reductions obtained through this program must not be required by any existing regulations, memoranda of agreement or understanding, or any legally binding document.

- Funded projects must operate for a minimum of five years and the agricultural stationary engine must be registered with the local district throughout the specified life of the project.

- Projects must meet a cost-effectiveness criterion of $13,600 per ton of NOx reduced.

- Priority must be given to stationary agricultural irrigation engine projects which result in the greatest amount of emission reductions (e.g., engine replacements with electric motors, engine repowers with certified engines, followed by engine retrofits). This is in line with the intent of the CMP to provide early emission reductions and produce the greatest air quality benefit.

POTENTIAL PROJECT TYPES

The CMP seeks near-term and cost-effective emission reductions from stationary diesel agricultural irrigation engines operating in California. Criteria were designed to ensure that the emission reductions expected through the deployment of electric motors, reduced-emission engines, or retrofit technologies under this program are real and quantifiable. All projects must meet a cost-effectiveness criterion of $13,600 per ton of NOx reduced. In addition, at the district discretion, eligible diesel repower projects may be subject to funding caps based on engine horsepower rating. The project must be operated for at least five years from the time it is first put into operation.

New Purchase with Electric Motors

Purchases of new agricultural irrigation pumps are allowed if equipped with electric motors. For the purposes of determining emission reductions, this new electric agricultural irrigation pump may be compared to a new pump powered by an off-road diesel engine certified to the current off-road NOx+NMHC emission standard.

Repower with Emission-Certified Engines

Under the revised CMP guidelines, a stationary agricultural irrigation pump engine repower substitutes an existing uncontrolled or emission-certified engine with a new or OEM-rebuilt off-road engine certified to the current applicable off-road NOx+NMHC emission standard. That is, presently, any diesel-to-diesel repower for agricultural pump applications requires the replacement engine in the 100 hp to 750 hp range to meet Tier 2 standards. Purchases of new emission-certified diesel off-road engines to repower existing uncontrolled diesel engines are expected to be the most common type of project for stationary agricultural irrigation pump engines under this program due to their wide availability and applicability. Purchases of new off-road SI engines to repower uncontrolled diesel engines are also allowed under the revised CMP guidelines. A gasoline-to-diesel repower project does not qualify for the CMP.

Technology for diesel-to-alternative fuel repower is available. However, an extensive number of SI engines have not gone through certification testing. The applicant may conduct emission tests for large SI engines in accordance with ARB approved test procedures for off-road engines and submit the test results along with the application. ARB LSI and U.S.EPA regulations establish testing programs and testing procedures. CMP funding cannot be used to cover the costs of certification testing.

The emission factors presented in this chapter have been revised and updated according to the recent version of the OFFROAD inventory model. The reader is also referred to Chapter 3 for broader discussions of off-road engine project requirements.

Replacement with Electric Motors

Replacement of uncontrolled engines with electric motors continues to be an option under the revised CMP guidelines. During the first year of the program, applications for electric motors were scarce. This was partly due to exclusion of infrastructure costs in determining the funding amount, which resulted in higher initial out-of-pocket costs to the applicant. In an electric pumping application, peripheral equipment is needed to supply electricity to the motor. The installed cost of a new certified diesel engine is comparable to the installed cost for an electric motor plus its necessary supporting components. Districts and utility companies have indicated that many diesel pump engines are situated next to existing electric lines, so no line extension would be needed. Considering the air quality benefits of electric motors, selected infrastructure costs for necessary equipment associated with the motor (e.g., control panel, motor leads, service pole with guy wire, connecting electric line) may be included in determining the grant amount awarded.

For remotely located irrigation pumps, some utility companies offer monetary line extension credits. Where a credit applies, the customer is responsible for the cost of the line extension (generally charged on a per foot basis) beyond what is covered by the credit. In most cases, costs associated with electric line extensions may not be covered with CMP funds. The only instance where CMP funds may be used toward line extensions is where the maximum amount to be funded plus other funded project costs do not exceed the $13,600 C/E limit. In these cases, the funds applied toward a line extension must come from the district and can be considered, if applicable, matching funds. This may only be applied where the applicant faces out-of-pocket expense above the line extension credit allowance (i.e., the needed line footage is outside the maximum distance provided free of charge).

Diesel-to-electric motor repowering projects are subject to the C/E of $13,600 per ton of NOx reduced and other criteria as presented.

Retrofits

Retrofit involves modifications to the engine and/or fuel system such that the retrofitted engine does not have the same specifications as the original engine. Retrofit projects may be applicable to certain off-road diesel engine families. The most straightforward retrofit projects are those that can be accomplished at the time of engine rebuild. This might entail upgrading certain engine and/or fuel system components to result in lower emission configuration. It is possible that emission control technologies that have been verified for use to reduce NOx and PM emissions in other applications for on-road or off-road diesel engines may be applicable to agricultural pumps. This type of project would qualify for funding if the uncontrolled and emission-certified engine retrofit kits are verified to meet a 6.9 g/bhp-hr NOx limit or a 15% NOx reduction, respectively.

Sample Application

Districts solicit bids for reduced-emission projects from off-road diesel equipment operators and make applications available upon request. A sample application form is included in the Appendix. The applicant must provide the minimum information illustrated in Table 6.3. Districts can request additional information.

EMISSION REDUCTION AND COST-EFFECTIVENESS

In general, the emission reduction benefit represents the difference in the emission level of an existing baseline and a reduced-emission replacement engine. In situations where the model year of the equipment and the model year of the existing engine are different, the model year of the engine will be used to determine the baseline emission factor for emission reduction calculations. The emission level is calculated by multiplying an emission factor, a conversion factor, and an activity level. Because the conversion factor and the activity level can be different for the baseline and replacement engine, the emission levels should be calculated first and prior to determining the difference in emissions. For a stationary agricultural irrigation pump, the activity level is typically expressed as annual hours of operation or annual fuel consumption. Thus, the type of records required to be maintained over the life of the project must be consistent with the calculation approach used, either one based on fuel consumption or hours of operation.

Table 6.3. Minimum Application Information Stationary Agricultural Irrigation Pump Projects.

1. Air District: 2. Applicant Demographics Company Name: Business Type: Mailing Address: Location Address: Contact Number: 3. Project Description Project Name: Project Type: Equipment Function: 4. NOx Reduction Incremental Cost Effectiveness Analysis Basis: (Mileage/Fuel/Hours of Operation) 5. VIN or Serial Number: 6. Application: (Repower, Retrofit or New) 7. Annual Diesel Gallons Used: 8. Hours of Operation: 9. Old Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year:	10. New Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year: Fuel Type: 11. NOX Emissions Reductions Baseline NOx Emissions Factor (g/bhp-hr): NOx Conversion Factors Used: Reduced NOx Emissions Factor (g/bhp-hr): Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions: 12. Percent Operated in California: 13. Project Life (years): 14. Cost ($) of the Base Engine: 15. Cost ($) of Certified LEV Engine: 16. PM Emissions Reductions Baseline PM Emissions Factor (g/bhp-hr): PM Conversion Factors Used: Reduced PM Emissions Factor (g/bhp-hr): Estimated Annual PM Emissions Reductions: Estimated Lifetime PM Emissions Reductions: 17. District Incentive Grant Requested:

In absence of manufacturer "guaranteed" emission factors, Table 3.4 in previous Chapter 3 offers default baseline NOx emission levels for pre-1996 model year diesel engines repower and retrofit projects. These reflect the recently adopted OFFROAD emission inventory model for off-road large CI engines greater than or equal to 25 hp. Load factor is an indicator of the amount of work required, on average, from an engine for a particular application and is given as a fraction of the engine horsepower rating. Default load factors for off-road equipment in agricultural applications listed in Table 3.5 must be used. The adopted OFFROAD emission inventory model reflects load factors ranging from 0.43 to 0.78 for both heavy-duty diesel engines in agricultural and construction applications. For applications or equipment not listed in Table 3.5, a default load factor of 0.43 must be used. The applicant continues to have the option of testing the baseline (uncontrolled) engine using an ARB approved test procedure to determine in-use emissions.

If annual hours of operation are the basis for determining emission benefits, the applicable conversion is the horsepower of the engine multiplied by load factor and activity level. Number of hours the equipment is in operation must be based on an hour meter. When annual fuel consumption is used, an energy consumption factor should be calculated and the activity level should be based on actual annual fuel receipts or equivalent documentation. The energy consumption factor converts the engine emission factor given in g/bhp-hr to g/gallon of fuel used. The reader is referred to Chapter 3 for discussion on the energy consumption or content factor. A default energy consumption factor for agricultural pump engines is 17.56 bhp-hr/gal of fuel. While actual fuel receipts support the annual fuel consumption of the existing baseline engine, the annual fuel consumption of the replacement reduced-emission engine is an estimate proportional to the change in the energy fuel consumption factor. For example, a reduced-emission engine having an energy content factor of 20 bhp-hr/gal and replacing a baseline engine, which uses 3,696 gallons/year and has an energy content factor of 17.56 bhp-hr/gal, would have an estimated annual equivalent fuel consumption of 3,245 gallons/year. Future fuel receipts or equivalent documentation must be submitted throughout the project life for verification of these estimates.

The portion of the cost for a repower to be funded by the CMP is the difference between the total cost of purchasing and installing the replacement engine (a new or newer emission-certified engine or a new electric motor) and the total cost of rebuilding the existing engine to its original specifications. Only the amount of money provided by the program and any local district match funding is to be used in the C/E calculations. The one-time incentive grant amount is to be amortized over the expected project life (at least five years) using a discount rate of 3%. The reader is referred to Chapter Three for discussion of the amortization formula using a capital recovery factor (CRF) and the discount rate.

Example 1
Agricultural Irrigation Pump Repower
Consider a farmer faced with the opportunity to replace a 1980 model year diesel engine rated at 120 hp used in an irrigation water pump with a new, certified off-road diesel engine rated at 150 hp during the normal rebuild period. In this case, the cost of the new, emission-certified diesel engine is $15,000 whereas the cost to rebuild the existing engine would be $6,000. The cost of a non-reset hour meter is $500. The old engine operated 2,000 hours annually. The project life is 7 years.

<u>Emission Reduction Calculation</u>

Baseline NOx Emissions:	13.0 g/bhp-hr
Baseline Horsepower:	120 hp
Baseline Load Factor:	0.51
Reduced NOx+NMHC Emissions:	4.9 g/bhp-hr
Reduced NOx Emissions:	0.95*4.9 g/bhp-hr=4.7 g/bhp-hr
Replacement Horsepower:	150 hp
Reduced Load Factor:	120 hp / 150 hp * 0.51=0.41
Annual Operating Hours:	2,000 hours/year
Conversion factor	1 ton=907,200 grams

(13.0 g/bhp-hr * 120 hp * 0.65) – (4.7 g/bhp-hr * 150 hp * 0.41) * 2,000 hrs/yr * ton/907,200 g = **1.6 ton/year NO emissions reduced**

Cost-Effectiveness Calculations

The annualized cost is based on the incremental project costs funded by the CMP, the expected life of the project (5 years at a minimum), and the interest rate (3%) used to amortize the project cost over the project life.

Incremental Capital Cost	= $ 15,500 - $ 6,000 = $ 9,500
Max. Amount Funded	= $ 9,500
Capital Recovery	**=** $[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 – 1] = 0.161$
Annualized cost	= $ 9,500 * 0.161 = $ 1530/year
Cost-Effectiveness	= ($ 1530/year)/(1.6 tons/year) = **$ 956/ton NOx reduced**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project qualifies for the maximum amount of requested of $9,500 assuming no local funding caps imposed by participating district.

Example 2
Agricultural Irrigation Pump Repower

Consider a similar example where an uncontrolled diesel engine (1980, 13 g/bhp-hr NOx) used to power an irrigation water pump is replaced with a new, certified off-road diesel engine (150 hp, 4.9 g/bhp-hr Nox+NMHC). The energy consumption factor for the uncontrolled engine is unknown while the energy consumption factor for the new engine is 19 bhp-hr/gal. The cost of the new, emission-certified diesel engine is $15,000 whereas the cost to purchase a rebuilt engine is $6,000. The farmer lists in the application that the new engine will use 4,600 gallons of fuel annually for a project life of 7 years. Since this farmer lists fuel consumption, a non-reset hour meter is not needed. The emission reduction and cost effectiveness for this project are calculated as follows:

Emission Reduction Calculation

Baseline NOx Emissions:	13.0 g/bhp-hr
Baseline Energy Consumption Factor:	17.56 hp-hr/gal (default value)
Baseline Annual Fuel Consumption:	4,600 gallons/year
New Engine NOx+NMHC Emissions:	4.9 g/hp-hr
New Engine NOx Emissions:	0.95*4.9 = 4.7 g/bhp-hr
New Engine Energy Consumption Factor:	19 hp-hr/gal
New Engine Annual Fuel Consumption:	(17.56 /19)hp-hr/gal * 4,600 gal/yr = 4,251 gal/yr
Conversion Factor:	1 ton=907,200 grams

[(13.0 g/bhp-hr * 17.56 hp-hr/gal * 4,600 gal/yr) – (4.7 g/bhp-hr * 19 hp-hr/gal * 4,251 gal/yr)] * ton/907,200 g = **0.74 tons/yr of NOx emissions reduced**

Cost-Effectiveness Calculations

The annualized cost is based on the incremental project costs funded by the CMP, the expected life of the project (7 years in this example), and the interest rate (3%t) used to amortize the project cost over the project life. Funding is determined as follows:

Incremental Capital Cost	= \$ 15,000 - \$ 6,000 = \$ 9,000
Max. Amount Funded	= \$ 9,000
Capital Recovery	**=** $[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 – 1] = 0.161$
Annualized cost	= \$ 9,000 * 0.161 = \$ 1,449/year
Cost-Effectiveness	= (\$ 1,449/year)/(0.74 tons/year) = **\$ 1,958/ton of NOx reduced**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project qualifies for the maximum amount of grant funds ($9,000) assuming no local funding caps imposed by participating district.

Example 3
Agricultural Irrigation Pump Electrification

Consider a farmer who applies for a Carl Moyer program grant for the purchase of an electric motor (150 hp) to replace an uncontrolled diesel engine (208 hp, 1980, 11 g/bhp-hr NOx) used to power an irrigation water pump. There is currently an electric power grid in the immediate vicinity of the pump and no electric line extension is needed. The installed cost of the new electric motor, control panel, motor leads, dropping a power line, and setting up a circuit breaker is $14,602 whereas the cost to rebuild the existing engine is $5,500. The cost of a non-reset hour meter is $300. The new engine will operate 2,000 hours annually for a project life of 7 years.

<u>Emission Reduction Calculation</u>

*Annual NOx Reductions (tons/year) = [(NOx Emission Factor * Load Factor * Horsepower)$_{Existing}$ – (NOx Emission Factor * Load Factor * Horsepower)$_{Replacement}$] * Annual Hours of Operation * (ton/907,200 grams)*

where,

Existing Engine NOx Emission Factor:		11.0 g/bhp-hr
Replacement Motor NOx+NMHC Emission Factor:		0 g/bhp-hr
Load Factor:		**0.51**
Baseline Horsepower:	208 hp	
Reduced Horsepower:	150 hp	
Annual Hours of Operation:	2,000 hours	

Estimated reductions are:

[(11.0 g/bhp-hr * 0.51 * 208 hp) – (0 g/bhp-hr * 0.65 * 150 hp)] * 2,000 hrs/yr * ton/907,200 g = 2.57 **tons/year NOx emissions reduced**

<u>Cost and Cost-Effectiveness Calculations</u>

The annualized cost is based on the incremental project costs funded by the CMP, the expected life of the project (7 years in this example), and the interest rate (3%) used to amortize the project cost over the project life.

Incremental Capital Cost	= \$14,602 - \$5,500 = \$9,102
Capital Recovery	= $[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 – 1] = 0.161$
Annualized Cost	= (0.161)(\$9,102) = \$1,461/yr
Cost-Effectiveness	= (\$1,461/yr)/(2.57 tons/yr) = **\$568/ton**

The project meets the cost-effectiveness limit of $13,600/ton NOx reduced. This project qualifies for the maximum amount of grant funds ($9,102).

Example 4
Agricultural Irrigation Pump "Diesel-to-Natural Gas" Repower

Consider a farmer faced with the opportunity to replace a model year 1980 diesel engine rated at 165 hp used to power an irrigation water pump. The farmer is replacing the existing uncontrolled engine (11 g/bhp-hr NOx) with a new, optionally certified off-road natural gas engine rated at 150 hp (4.5 g/bhp-hr Nox+NMHC) during the normal rebuild period. The cost of the off-road natural gas engine is $23,500 whereas the cost to purchase a rebuilt diesel engine is $5,500. The cost of a non-reset hour meter is $300. The new engine will operate 2,000 hours annually, for a project life of seven years.

<u>Emission Reduction Calculation</u>

Baseline NOx Emissions =	11.0 g/bhp-hr
Baseline Horsepower =	165 horsepower
Baseline Load Factor =	0.51
Reduced NOx+NMHC Emissions =	4.0 g/bhp-hr
Replacement Engine Horsepower =	150 horsepower
Replacement Engine Load Factor =	(165hp/150hp)*0.51=0.56
Annual Operating Hours=	2,000 hours/year
Conversion Factor=	1ton=907,200 grams

[(11.0 g/bhp-hr * 165 hp * 0.51) – (4.0 g/bhp-hr * 150 hp * 0.56)] * 2,000 hours/year * ton/907,200 g = **1.3 ton/year NOx emissions reduced**

<u>Cost-Effectiveness Calculations</u>

Incremental Capital Cost	= $ 23,800 - $ 5,500 = $ 18,300
Max. Amount Funded	= $ 18,300
Capital Recovery	= $[(1 + 0.03)^7 (0.03)]/[(1 + 0.03)^7 – 1] = 0.161$
Annualized cost	= $18,300 * 0.161 = $ 2,937/year
Cost-Effectiveness	= ($ 2,937/year)/(1.3 tons/year) = **$ 2,259/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced. This project qualifies for the maximum amount of grant funds ($18,300).

<u>Reporting and Monitoring</u>

Stationary agricultural engine operators participating in the CMP must keep appropriate records during the life of the project. During the project life, the district has the authority to conduct periodic checks or solicit operating records from the applicant that has received CMP funds. This is to ensure that the engine is being operated as stated in the project application. The applicant must maintain and update operating records throughout the project life and have them available to the district upon request. Annual records must contain, at a minimum, total actual hours of operations or estimated amount of fuel used. Actual hours of operations are acceptable for an engine equipped with a non-reset hour meter. The cost of the hour meter shall be included in the capital cost of the engine for determining an awarded. For electrification projects, the applicant must have documentation of payment to the local utility company for power installation.

Monitoring may be necessary to ensure the program incentives are being applied toward the project as specified in the application. It is recommended that districts conduct initial and/or periodic inspection of the equipment, especially when an electric motor is replaced for an internal combustion engine. To ease the tracking of the equipment over the life of the project, a district registration certificate may be issued to the equipment owner.

Chapter Seven
FORKLIFTS

This chapter provides information on forklift equipment types, forklift emissions, State and federal emissions standards by engine type, and ARB's two emission control strategies – replacing existing internal combustion engine (ICE) forklifts with electric forklifts and retrofitting ICE forklifts that do not lend themselves to electric substitution. This chapter also provides the specific project criteria used to establish funding eligibility under the CMP (Table 7.4), the cost-effectiveness criterion (including methodologies for determining emission reductions and cost-effectiveness for forklift equipment), and three example calculations.

FORKLIFT INVENTORY AND EMISSIONS

Forklifts are mobile vehicles powered by electric motors or internal combustion engines and used to carry, push, pull, lift, stack, or tier materials controlled by a rider or pedestrian operator, indoors or outdoors [ASME/OSHA]. Cranes and vehicles designed primarily for earthmoving, agriculture and forestry, as well as vehicles designed to operate on public streets or roads are not considered to be forklifts. Additionally, vehicles designed to move earth that have been modified to accept forks are not considered to be forklifts. Forklifts are used in a variety of applications, including, but not limited to, manufacturing, construction, retail, meat and poultry processing, lumber and building supplies, trades, agriculture, and a variety of warehouse operations.

The Industrial Truck Association (ITA) has defined seven classes of forklifts. These classes are defined by the type of engine, work environment (indoors, outdoors, narrow aisle, smooth or rough surfaces), operator positions (sit down or standing), and equipment characteristics (type of tire, maximum grade). Several classes are further divided by operating characteristics. Classifications are described in Table 7.1.

Table 7.1. Forklift Classes.

Class	Lift Code	Engine Type	Type/Use	Tire Type
1	1	Electric	Counterbalanced rider, stand up	Cushion or pneumatic (air filled)
1	4		Three-wheel, sit down	
1	5		Counterbalanced rider, sit down	
1	6		Counterbalanced rider, sit down	
2			Narrow aisle truck	Solid
3			Hand or hand/rider truck	
4		ICE	Rider, sit down, generally suitable for indoor use on hard surfaces	Cushion
5			Rider, sit down, typically used outdoors, on rough surfaces or steep inclines	Pneumatic
6		ICE; Electric	Ride on unit with the ability to tow at least 1,000 pounds; designed to tow cargo rather than lift it (e.g. an airport tug)	
7		ICE (primarily diesel)	Rough terrain forklift truck for outdoor use; almost exclusively powered by diesel engines	

Internal Combustion Engine Forklifts

According to the ARB off-road emissions inventory, there were more than 39,000 ICE forklifts with engines greater than 50 hp used in industrial applications in California in 1995. These estimates do not include large terrain forklifts or forklifts used at airport operations. Estimates for forklifts used in airport operations are discussed in the airport ground support equipment chapter. Total NOx emissions from industrial forklifts greater than 50 hp in California are estimated to have been 62.1 tons per day in 1995, and are estimated to be 37.1 tons per day in 2010, with the decrease primarily attributable to new emission standards. ICE forklifts are fueled with gasoline, propane, natural gas, or diesel. Table 7.2 contains the most current ICE forklift population and NOx emission estimates.

Table 7.2. 1998 Population and NOx Emission Estimates For Industrial Forklifts with Internal Combustion Engines California and South Coast Air Basin Data.

Horsepower Range	Fuel	Population		NOx Emission (tons per day)	
		SCAB	State	SCAB	State
50≤ hp <120	Gasoline	4,610	9,318	6.5	13.1
50≤ hp <120	CNG, Propane	9,914	17,638	12.3	22.0
50≤ hp <120	Diesel	1,634	3,303	3.07	6.0
120≤ hp <175	Gasoline	168	340	0.6	1.1
120≤ hp <175	CNG, Propane	362	645	1.0	1.7
120≤ hp <175	Diesel	167	337	0.5	0.9
>175 hp	Diesel	67	136	0.3	0.6
Total		**16,922**	**31,717**	**24.2**	**45.1**

Electric Forklifts

The ARB inventory does not contain information on the number of electric forklifts in California. Most of the information on the type of forklifts bought and used is considered to be confidential within the industry. Forklift population estimates that have been developed by Electric Power Research Institute (EPRI) and other sources generally rely on ITA shipment data. Data reviewed by ARB staff indicates that there are about 70,000 electric forklifts in California. Roughly 50,000 of those are the smaller hand trucks and narrow aisle trucks (classes 2 and 3), and about 20,000 of those are electric rider forklifts. Electric forklifts have zero exhaust emissions.

Emission Standards

Internal combustion engine forklifts can either be powered by CI engines (usually diesel fueled) or by SI engines (which use gasoline, CNG, or propane fuel). Both the ARB and U.S.EPA prescribe emission standards for off-road equipment including forklifts. There are separate emission standards for large spark-ignited (LSI) engines and CI engines.

Off-road equipment is also split into two broad categories: less than 175 hp and equal to or greater than 175 hp. Both of these categories include forklifts. Currently, ARB is preempted from regulating new farm and construction equipment less than 175 hp. However, ARB has the authority to regulate non-preempted off-road equipment less than 175 hp and off-road equipment equal to or greater than 175 hp.

Large Spark-Ignited Off-Road Engine Standards

Forklifts with SI engines are commonly used indoors, and typically have lift capacities between 3,000 and 16,000 pounds. A report prepared for the Gas Research Institute indicated that about 45% of SI forklifts (class 4 and 5) have engines rated 50 hp or lower [GRI 1995]. On an ICE forklift, a 45 to 50 hp engine generally has a lift capacity of 6,000 to 7,000 pounds. Propane is the fuel that is most widely used in spark-ignited engines, compared to gasoline or compressed natural gas.

Spark-ignited engines greater than 25 hp are classified as LSI engines by ARB. ARB has regulations for new LSI off road engines that establish exhaust emission standards and test procedures. Table 7.3a contains the LSI emission standards that were approved by ARB.

Table 7.3a. Exhaust Emission Standards New Large Spark-ignited Engines.

Year	**Engine Size**	**NMHC + NOx (g/bhp-hr)**	**CO (g/bhp-hr)**	**Durability Period**
2002 & later	<1.0 liter	9.0	410	1000 hours or 2 years
2001-2003 (Phase-in)	>1.0 liter	3.0	37	N/A
2004-2006	>1.0 liter	3.0	37	3500 hours or 5 years
2007 & later	>1.0 liter	3.0	37	5000 hours or 7 years

Note: The standard for in-use compliance for engine families certified to the standards noted above shall be 4.0 g/bhp-hr (5.4 g/kW-hr) hydrocarbon plus oxides of nitrogen and 50.0 g/bhp-hr (67 g/kW-hr) carbon monoxide for a useful life of 5000 hours or 7 years.

In addition to the ARB LSI standards, the U.S.EPA finalized new nationwide emission standards for LSI engines in 2002. These standards were based on data generated during U.S. EPA-, ARB- and South Coast AQMD-sponsored catalyst durability testing in 2000. The testing showed that LSI engines could meet exhaust emission levels well below the current ARB standards using three-way catalysts and closed-loop fuel control.

Table 7.3b. Proposed Exhaust Emission Standards[1] New Large Spark-ignited Engines.

Year	**Engine Size**	**NMHC + NOx (g/bhp-hr)**	**CO (g/bhp-hr)**	**Durability Period**
2007	>1.0 liter	2.0	3.3	5000 hours or 7 years

Note: Manufacturers must certify to these levels utilizing both a steady state and transient test cycles. In addition, manufacturers may optionally certify engines according to a formula based on an HC+NOx/CO tradeoff. However, an engine cannot be certified to an HC+NOx standard above 2.0 g/bhp-hr or a CO standard above 15.4 g/bhp-hr.

The new U.S. EPA standards align with California's LSI standards beginning in the 2004 model year. Beginning in 2007, however, U.S.EPA's Tier 2 standard for LSI engines becomes more stringent than the ARB standard. Table 7.3b contains the new 2007 standard. ARB staff will be proposing to adopt exhaust emission standards in 2003 that align with the federal Tier 2 standard beginning with the 2007 model year.

In 2004, ARB staff will propose a fleet rule that will include a retrofit control measure for in-use LSI engines as well as electric purchase requirements as discussed below. Recent data have shown that existing LSI engines retrofitted with catalyst-based emission systems could achieve emission reductions similar to those achieved from new engines designed with catalysts. ARB currently has no regulations limiting emissions from pre-2001 model year spark-ignition engines over 25 hp, and some uncontrolled engines can be sold in California through the 2003 model year. Engines subject to the measure would use a three-way catalyst and closed-loop fuel system to achieve an 80% reduction in exhaust emissions or meet emission levels equivalent to 3.0 g/bhp-hr HC+NOx. The retrofit measure would be implemented in phases during the 2006-2012 time period. Once the measure becomes effective, only surplus emission reductions from LSI engine forklifts – beyond that required by the retrofit control measure – may be eligible for CMP funding.

Diesel Off-Road Engine Standards

Compression-ignition engines (diesel) are often used to power forklifts that have large payload requirements. Almost all diesel forklifts have lift capacities over 6,000 pounds, and are available with lift capacities exceeding 40,000 pounds. Diesel forklifts are subject to ARB and U.S.EPA off-road CI engine emission standards. The ARB adopts emission standards for off-road diesel cycle or CI engines equal to or greater than 175 hp. As with LSI engines, the ARB is preempted from regulating new farm and construction equipment less than 175 hp. Instead, the ARB works closely with the U.S.EPA and relies heavily on federal action to regulate these engines to obtain needed emission reductions from CI engines in the 50 to 175 hp range.

In 1996, the U.S.EPA, ARB, and off-road diesel engine manufacturers signed a Statement of Principles (SOP) that set forth comprehensive future emission standards for CI (diesel) off-road engines. The SOP provides for NOx or NMHC+NOx, PM, and carbon monoxide (CO) emission standards for new engines to be phased-in from 2003 through 2008. U.S.EPA has adopted regulations for off-road diesel equipment consistent with the emission levels contained in the SOP. In January 2000, the ARB amended California's regulations for off-road equipment to harmonize with federal regulations. The reader is referred to Chapter 3, Table 3.1 for a list of all applicable standards for off-road diesel engines.

ARB staff believes that off-road CI engines can meet more stringent emissions standards with the incorporation of advanced emission control technology. Staff is working closely with the U.S.EPA and industry to establish new nationwide Tier 4 NOx and PM emission standards. Staff anticipates the Tier 4 standards will be based on the use of technologies such as NOx adsorbers and diesel particulate filters. The introduction of low sulfur diesel fuel will accompany the Tier 4 emission standards. A proposal to align the California off-road CI engine standards with the Tier 4 requirements in 2004 is expected. These actions could reduce engine out NOx and PM emissions by approximately 90 percent as compared to already approved Tier 3 standards.

As with LSI engines, the ARB staff is proposing one or more retrofit control measures to accompany the current and proposed emission standards for CI engines. To be adopted in the 2004-2008 time frame, the measure(s) would specifically address PM emissions from existing heavy-duty off-road equipment, but would provide reactive organic gas (ROG) emission reductions as well. The measure(s) would not prescribe the emission control strategies, but instead would allow operators to choose from a variety of ARB-verified strategies or ARB-certified engines to meet the emission reduction targets specified by the measure(s). Examples of strategies include installation of diesel particulate filters, replacement of older engines (engine repower) and replacement or retirement of older vehicles. The use of low-sulfur diesel fuel may be an integral strategy component. Because it would be difficult to track certain types of retrofitted off-road equipment, hampering the ability to directly enforce the retrofit installation, the ARB staff is considering a proposal that would require registration of off-road equipment as discussed below.

<u>Other Proposed Control Measures</u>
In addition to the current and proposed emission standards and proposed retrofit requirements for both LSI and CI engines, ARB staff will propose a measure for adoption in 2003-2004 that would require only electric forklift purchases. The rule would apply to companies that use forklifts and companies that offer forklifts for rental. The rule would be limited to forklifts of less than or equal to 8,000 pounds lift capacity purchased after January 1, 2005. Rental companies would have until December 31, 2009 to phase out non-electric forklift rentals. Once this rule becomes effective, electric forklifts of less than or equal to 8,000 pounds lift capacity may no longer be eligible for CMP funding.

ELECTRIC FORKLIFTS

Electric forklifts include electric motor trucks with cushion or pneumatic tires (Class 1); electric motor narrow aisle trucks (Class 2); and electric hand trucks or hand/rider trucks (Class 3). Class 1 electric forklifts are available in a wide variety of lift capacities from 3,000 pounds to 20,000 or greater pounds. According to market data evaluated by ARB, most class 1 forklifts sold today in the U.S. are in the 3,000-6,000 pound lift capacity range. There does not appear to have been a large penetration of electric class 1 forklifts with lift capacities greater than 6,000 pounds in the current California or U.S. market.

Electric forklifts are most typically used in indoor materials handling applications that do not require large lift capacities (i.e., warehouse/retail operations). There are some applications where electric forklifts are used extensively, primarily for worker safety. These applications include confined spaces, cold storage, and food retail (primarily grocery stores).

Although electric forklifts are primarily designed for indoor operations, a number of manufacturers are also including equipment features, which enable electric models to be used in a wider variety of environments. These features include pneumatic tires (air filled), which allow the forklift to be used on unimproved surfaces, water proofing trucks or sealing the electronic compartment to make them more water resistant for outdoor conditions, and alternating current (A.C.) motors that provide greater lift and travel speeds. Class 1 forklifts (electric) compete directly with ICE forklifts for many of the same work applications.

Electric forklifts have no exhaust emissions, and extremely low upstream (power plant) emissions. Thus electric forklifts can provide significant air quality benefits. EPRI has prepared several reports on electric forklifts that identify other benefits of electric forklift usage besides improved air quality. One benefit is that electric forklifts have lower life cycle costs when compared with ICE models. This is due to lower maintenance costs, lower fueling costs, and longer useful life for an electric forklift. Although the initial capital cost is higher for an electric forklift as compared with the ICE forklift, the incremental cost can be recovered during the useful life of the electric forklift. Because of the financial benefits to the end user, electric forklifts are already prevalent in some markets.

CONTROL STRATEGIES

There are two control strategies that promise to reduce NOx emissions from ICE forklifts: electric substitution and ICE retrofit. This section discusses each control strategy and its relation to the CMP project criteria.

<u>Electric substitution</u>

Electric forklifts have been widely used for a number of years in the U.S.. Increasing the use of electric forklifts by substituting electric forklifts for ICE forklifts would reduce NOx emissions. Replacing an older electric forklift with a newer electric model, however, does not reduce emissions. The project criteria for forklifts have been designed to require the substitution of an ICE forklift with an electric forklift and to exclude projects where "electric to electric" replacements are likely to occur or where electric forklifts already dominate the market. The following sections outline the strategies behind the electric forklift project criteria.

Forklift Class -

Class 1 forklifts are the electric models that compete with ICE forklifts because they are similar in design and specification. Class 1 forklifts can be used in many of the same work applications as an ICE (class 4 or 5) forklift. Increasing the use of class 1 forklifts relative to class 4 and 5 forklifts would reduce NOx emissions. Class 2 and 3 forklifts generally do not compete with ICE forklifts. Since these classes are solely electric forklifts, and “electric-to-electric” replacements do not yield NOx reductions, Class 2 and 3 would be excluded from funding under the CMP.

Class 6 trucks are ride-on vehicles designed to tow at least 1,000 pounds. Airport tugs are an example of a Class 6 truck. Class 6 trucks that are used in airport ground support equipment (GSE) applications may be eligible for CMP funding. See the chapter on GSE for additional details.

Rough terrain forklifts (Class 7) are primarily powered by diesel engines. Therefore, Class 7 forklifts would be eligible for CMP funding. However, since electric or alternatively fueled options are not currently available for Class 7 forklifts, these types of projects are not anticipated.

Industry Application -
The most viable control strategies would include funding electric forklifts that replace ICE forklifts in applications where electric forklifts are not commonly used. These control strategies would include construction, millwork, cargo handling, lumber, plywood, foundries, and metal work. Conversely, there are several applications where electric forklifts are used extensively, as compared to ICE forklifts. These industrial applications include confined spaces (such as freezers), cold storage, and food retail (primarily grocery stores). Since electric forklifts are commonly used in these industrial applications, "electric-to-electric" replacements would also be common. Hence, forklift purchases or replacements in industries whose primary business includes confined spaces, cold storage, and food stores are excluded from the CMP.

Forklift Rental -
Market data prepared for the Gas Research Institute indicates several interesting trends regarding forklift usage and ownership [GRI1995]. Approximately 55% of Class 1 and 2 forklifts are owned by the end user, 15% are rented (short-term rentals), and 30% are full service leases. The proportion of purchased, rented, and leased ICE forklifts (class 4 and 5) is similar.

Full service leases are an attractive option to many companies because they reduce the up-front capital costs associated with the purchase of new forklift equipment. Rented and leased-to-own equipment can be deployed in a wide variety of fleets and work applications. There is no practical way to ensure that leased or rented electric forklifts are replacing an ICE forklift, and not an "electric-to-electric" replacement. Even if the staff proposal to require that all new 8,000 pound or less forklift purchases and rentals be electric (see section C.3.) is adopted, there would be no way to ensure that rented electric forklifts were not an "electric-to-electric" replacement. Therefore, rented and leased equipment is currently excluded from the CMP.

There are a number of issues associated with leased equipment, such as free-ridership (electric-to-electric replacements), enforcement, and incremental capital costs. Due to the lower maintenance and operation costs associated with leasing an electric forklift over an ICE forklift, there can be some cost benefits with leasing an electric forklift. Since reduced costs are already an incentive to the end user, it is hard to determine if an electric forklift would have still been leased without CMP funding as the incentive. Furthermore, it is also difficult to determine the appropriate incremental cost to fund, since an electric forklift may already provide some incentive to the end user. Although project proposals involving leased equipment may seem to be viable, it is still necessary to ascertain the conditions under which leased equipment could be incorporated into the CMP. Therefore, only leased-to-own equipment for certain projects would be eligible for funding under the Demonstration Program (discussed later in this document).

Hours of Usage -
The report prepared for the Gas Research Institute also indicates that the annual hours of usage varies significantly between industries [Fork2]. For electric forklifts, the range varies from 500 hours to 3,500 hours a year, with an average of about 2,250 hours/year. The average annual hours of usage for an ICE forklift are 1,800-1,900 hours/year.

The Gas Research Institute report also estimated that two thirds of electric forklifts are purchased new, while one third are purchased used [Fork2]. New electric forklift purchasers often record twice the operating hours as used forklift purchasers. Because of the reduced usage and life expectancy of older equipment, only the purchase of new electric forklifts will be funded under the CMP. In addition, all projects will be required to have an hour meter on each forklift, and track annual hours of operation for the project life (five years). This is to ensure that the emission benefits of the project are realized.

Battery Charger -
The existence of a battery charger at a facility is a good indication that that business or fleet is currently using an electric forklift. In order to ensure that the CMP is funding replacement of an ICE forklift with an electric forklift, and not an electric-to-electric replacement, all projects will be required to purchase battery chargers. The number of chargers purchased must correspond to the number of forklifts purchased. There may be some cases, however, where a charger for every forklift is not necessary (for example, operations that incorporate daily multiple shifts, or facilities that have fast-charging equipment). Applications where the number of chargers differs from the number of forklifts will be evaluated on a case-by-case basis. Chargers are not eligible for CMP funding because the CMP Guidelines prohibit funding for infrastructure, and the chargers constitute infrastructure.

Multiple Shift Operations -
According to the Gas Research Institute report, on average, both electric and ICE forklifts operate 1.5 shifts a day, five days a week [Fork2]. Sixty-nine percent of class 1 and 2 (electric) forklifts operate one shift a day, 16% operate two shifts, and 15% operate three shifts. According to the survey, on average, an electric (class 1 or 2) forklift is recharged after 11 clock (not meter) hours. Thus, electric forklifts operating in multiple shifts typically use multiple battery packs and battery change out equipment. For ICE forklifts, 59% operate one shift, and almost 40% operate two shifts. The average propane tank is replaced or refilled after 15 hours. Both electric and ICE forklifts can sit idle for a significant portion of the shifts during which they are used. Furthermore, the usage pattern can vary from continual use to 4 or 5 hours per shift. The CMP will fund the purchase of one battery pack per forklift purchased. Applications indicating a request to fund multiple battery packs that may be needed for multiple shift operations will be considered on a case-by-case basis. Documentation indicating the extensive use will be required.

New and Expanding Facilities -

It is difficult to determine a company's commitment to electric forklifts without extensive details about the makeup of their existing fleet. To be funded under the CMP, a company with multiple facilities that is preparing to open a new facility must demonstrate a commitment to significantly increase the percent of electric forklifts over ICE forklifts in the company's fleet. Similarly, a company preparing to expand an operation must demonstrate that the expansion includes a physical change, such as a 25 percent increase in square footage. Facility expansions that increase square footage by less than 25% may be considered on a case-by-case basis.

<u>ICE Retrofit</u>

The second NOx emission reduction strategy addresses the realization that electric forklifts will not replace all LSI ICE forklifts. The proposed electric forklift control measure discussed earlier only affects new forklifts with a lift capacity of 8,000 pounds or less. Existing ICE forklifts with a lift capacity of 8,000 pounds or less and new forklifts with a lift capacity exceeding 8,000 pounds (primarily Class 5 and 7) will not be subject to the control measure. To achieve NOx emissions reductions from these forklifts, staff has added project criteria to this chapter that would allow the incremental cost of a catalytic muffler-type retrofit control device to be eligible for funding under the CMP. The only eligible retrofit devices are those that have either been verified by the ARB or technically evaluated by ARB and deemed to achieve the prescribed emissions reductions. The ICE retrofit control option was not considered for CI engines because proposed retrofit control measures for CI engines may become effective as soon as 2004. The following sections outline the strategies behind the forklift retrofit project criteria.

Forklift Class -

Class 4, 5 and 7 LSI ICE forklifts would be eligible for funding under the CMP. However, electric Class 1 forklifts compete well with Class 4 and 5 forklifts in many applications. Features such as pneumatic tires (air filled) that allow the forklift to be used on unimproved surfaces, water-proof trucks and electronic compartments to make them water resistant for outdoor conditions, and especially alternating current (A.C.) motors that provide greater lift and travel speeds blur the differences in capabilities between electric and ICE forklifts. To encourage electrification, when considering CMP funding for the electric replacement or ICE retrofit of Class 4 and 5 forklifts with a lift capacity of less than 8,000 pounds, ICE to electric conversions may be favored over ICE retrofits.

Industry Application -

ICE forklifts used in an application where electric forklifts are already used extensively would be excluded from the CMP. These applications include confined spaces (such as freezers), cold storage, and food retail.

Forklift Rental -

As discussed previously, ARB staff is already proposing to require that all new forklift purchases and rentals (with a lift capacity of less than 8,000 pounds) be electric. Once the control measure is fully implemented, all forklifts offered for rent with a lift capacity of less than 8,000 pounds would have to be electric. However, rental and leased-to-own ICE forklifts with 8,000-pound lift capacity or greater would still be eligible for CMP funding.

Hours of Usage -
Unlike the electric substitution strategy, the retrofit strategy is specifically for used forklifts. The shorter life expectancy and limited operating schedules of used forklifts engender a concern that the emission benefits of the project will not be realized. To be eligible for CMP funding, an owner will need to certify that the used forklift has at least a five-year (9,500 hour) service life remaining. All projects will be required to have an hour meter on each forklift, and track annual hours of operation for the project life (five years).

PROJECT CRITERIA
Electric replacement or ICE retrofit forklift projects must meet the specific criteria listed in Table 7.4 below. In general, Class 1 electric forklifts are eligible for funding under the Electric Replacement option and Class 4, 5, and 7 forklifts are eligible for funding under the ICE Retrofit option. Projects must meet a C/E criterion of $13,600 per ton of NOx reduced to qualify for funding, except that forklifts with 3,000 - 6,000 pound lift capacity have a separate C/E criterion of $3,100. A forklift funded under the project must be operated for at least five years from the time it is first put into operation (electric) or retrofitted (ICE), and for at least 75% of the time in California.

All new electric forklifts are eligible for CMP funding through 2004. Beginning in 2005, the electric forklift purchase control measure would require that companies purchasing new forklifts with a lift capacity of 8,000 pounds or less purchase only electric forklifts. Rental companies would have until the end of 2009 to phase out non-electric rentals. As companies are required by the control measure to purchase electric forklifts, they would no longer be eligible for CMP funding. Companies requiring forklifts with a lift capacity exceeding 8,000 pounds would still be eligible for CMP funding.

All existing LSI engines are eligible for retrofit funding through 2005. During the 2006-2012 phase-in of the retrofit control measure, those LSI engines not yet subject to the measure would still be eligible for funding, provided that the emission benefit calculations (cost-effectiveness) are within CMP Guidelines for dollar cost per ton of emissions reduced.

Funding for electric forklifts with a lift capacity of less than 6,000 pounds was provided via a demonstration project in the SCAQMD during the first two years of the CMP. Under this demonstration program, SCAQMD staff was successful at incentivizing electric forklift projects that would not likely have occurred without funding. In addition, the SCAQMD staff determined that it was appropriate to set a C/E criterion of $3000 per ton of NOx reduced for forklift projects. Funding for electric forklifts with lift capacities of

3,000 through 6,000 pounds would be allowed under the CMP, however those forklift projects would have separate project criteria and a C/E criterion of $3,100 per ton of NOx reduced after adjustment for cost of living increases.

Table 7.4. Carl Moyer Program Forklift Project Criteria.

Criterion	Control Option: Electric Forklift Purchase	Control Option: ICE Retrofit
Class 1, lift codes 5 or 6 (four-wheel counter-balanced sit-down) electric forklifts plus one battery pack for each forklift purchased are eligible for CMP funding until the Electric Forklift Purchase control measure becomes effective (2005 – 2009 phase in). As companies are required by the control measure to purchase electric forklifts, they will no longer be eligible for CMP funding. Companies requiring forklifts with a lift capacity exceeding 8,000 pounds would still be eligible for CMP funding	✔	
Class 1, lift codes 1 or 4 (Stand up or three-wheel sit-down rider), Class 2 (narrow aisle), and Class 3 (hand/rider trucks) electric forklifts are not eligible.	✔	
Class 4, Class 5 and Class 7 LSI forklifts are eligible for CMP funding until the ICE Retrofit control measure becomes effective (2006 – 2012 phase in). During the phase-in period, those LSI engines not yet subject to the measure would still be eligible for funding.		✔
The ICE Retrofit control option is limited to forklifts with LSI engines. CI engines may be subject to retrofit control regulations in 2004 and NOx reductions for CI engine retrofits have not yet been quantified.		✔
Any existing regulations or binding agreements must not require NOx reductions obtained through this program.	✔	✔
For existing, new, and expanding facilities, all forklifts must be purchased new or leased-to-own.	✔	
All applicants must purchase new forklifts for use by the applicant. Organizations or businesses that rent out or lease-to-own are not eligible for funding. Rental or leased equipment costs are also not eligible for funding.	✔	
All projects that include leased-to-own equipment must have a signed contract with the air district that specifies the end user will keep and use the equipment for five years.	✔	
Assume an 11-year useful life for existing ICE forklifts. The useful life must carry them through the required five-year project life.[1]	✔	✔
All expanding facilities must provide documentation that indicates a significant physical change in the facility, such as a 25% or greater increase in square footage. Expansions of less than 25% may be considered on a case-by-case basis.	✔	

[1] 99% of the forklifts in ARB's OFFROAD inventory are 11 years old or newer.

Criterion	Control Option	
	Electric Forklift Purchase	ICE Retrofit
All eligible projects must also include the installation of battery chargers that correspond to the number of forklifts purchased.[2] Battery chargers are considered infrastructure and cannot be included as project costs.	✔	
All eligible projects will be required to have an hour meter on each forklift, and track annual hours of operation.	✔	✔
All eligible projects must sign a declaration that the applicant is not replacing an old electric forklift with a new electric forklift.	✔	
For existing and expanding facilities, the ICE forklift that is being replaced (electric forklift purchase option) must have a lift capacity commensurate with that of the new electric forklift.	✔	
Emission reductions will be performed in consideration of pending regulations. Emission reductions cannot be claimed for any portion of the five-year project life subsequent to a regulation becoming effective.	✔	✔
Forklifts used in commercial (passenger) and military airport operations were not included in the forklift emissions inventory. They may be eligible for funding provided they meet both forklift and GSE project criteria.	✔	
The following industries are not eligible for funding under this program: food retail stores, cold storage, and confined space operations (such as freezers).	✔	✔
Cost-effectiveness is $13,600 per ton of NOx reduced for (1) electric replacement of forklifts with 6,000 pound or more lift capacity, or (2) ICE retrofit of existing forklifts. Cost-effectiveness for a forklift with 3,000 – 6,000 pound lift capacity is $3,100 per ton of NOx reduced.	✔	✔
All projects must meet general Carl Moyer Program requirements, which include using a minimum allowable project life of five years for calculating project benefits, and a minimum of 75% equipment operation in California.	✔	✔
Before being approved for funding, applicants would have to provide District staff with the following information, at a minimum: 1) whether fuel switching is occurring; 2) whether an electric forklift is replacing an ICE forklift; 3) the customer plans for ICE forklifts that are replaced; and 4) hours of operation. Funding will not be approved if staff determines that the electric forklifts are replacing older electric forklifts, and not ICE forklifts.	✔	
As a condition of funding, the applicant will agree to participate in the monitoring program as described in this chapter.	✔	✔
For reporting purposes, information on forklifts must include, *as applicable*, hours of operation (i.e., hours of use, kilowatt-hour use, and hours in idle); the relationship between horsepower and lift capacity; and the cost of charging equipment (including installation). All proprietary and confidential information is protected.	✔	✔

[2] Multiple shift operations and facilities that have fast charging equipment may not be required to install chargers at a one-to-one ratio. Applicants will have to demonstrate why they should not have to provide as many battery chargers as forklifts purchased.

EMISSION REDUCTION AND COST-EFFECTIVENESS

<u>Emission Reduction Calculation</u>

The emission reduction benefit will be calculated for NOx emissions only and will be determined using the annual hours of operation. Annual NOx emission reductions are determined by multiplying the difference in the NOx emission levels by the rated horsepower of the engine, the load factor, and the hours the engine is expected to operate per year. The difference in the NOx emission levels is a comparison between the baseline (existing) engine and the reduced (electric or retrofit) engine. The load factor is an indication of the amount of work done, on average, by an engine in a particular application, given as a fraction of the rated horsepower of that engine. If the actual load factor is known for an engine it should be used in calculating emission reductions. If the actual load factor is not known, the default value of 0.30 will be used; this is the load factor used in the ARB inventory for all non-construction forklifts (all fuels). Another variable in determining emission reductions is the number of hours the equipment operates. If actual hours of equipment operation are not available, the default value of 1,900 annual hours should be used to calculate emission reductions.

Applicants requesting funding under either the electric forklift substitution control option or the ICE forklift retrofit control option must calculate their emission reduction benefits using the baseline NOx emission rates listed in Table 7.5 below. Applicants choosing the electric forklift substitution control option will select the baseline rate corresponding to the model year of the new ICE forklift that would have been purchased had an electric substitution not occurred. Applicants choosing the ICE forklift retrofit control option will select the baseline rate corresponding to the model year of their existing ICE forklift.

The emission reduction benefit must also factor in the pending electric forklift purchase and ICE retrofit control measures. The electric forklift purchase control measure will require, beginning in 2005, that all new forklifts of 8,000 pounds or less lift capacity intended for sale or rent in California be electric forklifts. Thus, applicants requesting funding under the electric forklift substitution control option may only claim emission reduction benefits for the years prior to the 2005 effective date (inclusive of the application year). The ICE retrofit control measure (LSI only) will require, beginning in 2006, that existing LSI engines not certified as compliant with ARB's post-2000 model year standards be retrofitted with a three-way catalyst and closed-loop fuel system to achieve an 80% reduction in exhaust emissions or meet emission levels equivalent to 3.0 g/bhp-hr HC+NOx. Applicants requesting funding under the ICE forklift retrofit control option may only claim emission reduction benefits for the years prior to the 2006 effective date of the proposed control measure (inclusive of the application year). Emission reduction benefits may not be claimed for the portion of the five-year project life subsequent to the electric forklift purchase and ICE retrofit control measures becoming effective. Instead, for both control options, the emission reduction benefits derived during the portion of the project life prior to the effective dates of the control measures must be apportioned over the entire five-year project life.

Cost-Effectiveness Calculation

The incremental cost of an electric forklift project to be funded through the CMP is the difference between the cost of purchasing a new electric forklift and buying a new conventional forklift. Only the amount of money provided by the CMP and any local district matching funds can be used in the C/E calculations. The one-time incentive grant amount is to be amortized over the expected project life (at least five years) with a discount rate of three percent. The amortization formula (given below) yields a capital recovery factor, which when multiplied with the initial capital cost, gives the annual cost of a project over its expected lifetime.

$$\textit{Capital Recovery Factor (CRF)} = [(1 + i)^n (i)] / [(1 + i)^n - 1]$$

where, i = discount rate (3%)
n = project life (at least five years)

Cost-effectiveness is then determined by dividing the annualized cost by the annual NOx emission reductions apportioned over the five-year project life. For the purposes of explaining the emission reduction and the cost effectiveness calculations from a particular forklift project, three examples are presented below. The first example describes the calculations based on replacing an existing diesel forklift with an electric counterbalanced sit-down rider electric (class 1) forklift. The second example shows calculations for the replacement of a propane forklift. The third example shows calculations for the retrofit of a propane forklift.

Table 7.5. Baseline Emission Rates for Forklift Engines by Model Year[3].

Rated Power (horsepower)	Type of Engine	Model Year	Emission Standards/Rates (g/bhp-hr) NOx	NMHC +NOx
25 $\leq$ hp < 50	Compression ignition (diesel)	2000-2003	--	7.1
		2004 +	--	5.6
50 $\leq$ hp < 100	Compression ignition (diesel)	Pre-2000	8.75[4]	--
		2000-2003	6.9	--
		2004 +	--	5.6
		2008 +	--	3.5
100 $\leq$ hp < 175	Compression ignition (diesel)	Pre-2000	8.17[5]	--
		2000-2002	6.9	--
		2003 +	--	4.9
		2007 +	--	3.0
25 < hp $\leq$ 50	Large Spark-ignited (propane) Uncontrolled	Pre-2002	13.0[6]	--
		2002 +	--	9.0[7]
> 50 hp	Large Spark-ignited (propane) Uncontrolled	Pre-2001	10.5[8]	--
		2001-2006	--	3.0[9]
		2007 +	--	2.0[9]
25 < hp $\leq$ 50	Large Spark-ignited (gasoline) Uncontrolled	Pre-2002	8.0[10]	--
		2002 +	--	9.0[11]
50 < hp < 120	Large Spark-ignited (gasoline) Uncontrolled	Pre-2001	11.8[12]	--
		2001-2006	--	3.0[9]
		2007 +	--	2.0[9]
> 120 hp	Large Spark-ignited (gasoline) Uncontrolled	Pre-2001	12.9[13]	--
		2001-2006	--	3.0[9]
		2007 +	--	2.0[9]

Reference: California Off-Road Large Spark-Ignited Engine Emissions Inventory (October 1998)

3 Emission standards are provided where uncontrolled emission rates are not available.
4 Emission rate for uncontrolled off-road heavy-duty diesel engines of 50 to 120 horsepower.
5 Emission rate for uncontrolled off-road heavy-duty diesel engines of 120 or more horsepower.
6 Emission rate for uncontrolled off-road heavy-duty propane engines of 25 to 50 horsepower.
7 This emission standard is for propane or gasoline LSI engines with a displacement of 1.0 liter or less.
8 Emission rate for uncontrolled off-road heavy-duty propane engines of 50 or more horsepower.
9 This emission standard is for propane or gasoline LSI engines with a displacement of more than 1.0 liter.
10 Emission rate for uncontrolled off-road heavy-duty gasoline engines of 25 to 50 horsepower.
11 This emission standard is for propane or gasoline LSI engines with a displacement of 1.0 liter or less.
12 Emission rate for uncontrolled off-road heavy-duty gasoline engines of 50 to 120 horsepower.
13 Emission rate for uncontrolled off-road heavy-duty gasoline engines of 120 or more horsepower.

Example 1
Calculations for replacement of a diesel forklift, based on hours of operation
A forklift owner applies for a Carl Moyer Program grant for the purchase of a new counter-balanced sit-down rider electric forklift to replace an existing diesel-powered ICE forklift with a lift capacity of 6,000 pounds or more. The forklift owner has decided to purchase a new electric forklift instead of purchasing a new diesel forklift certified to a 6.9 g/bhp-hr NOX standard. The cost of the new electric forklift is $39,900, plus $4000 for the battery, whereas the cost to buy a new diesel ICE forklift is $35,730. The new forklift will operate 1900 hours annually and will operate 100 percent of the time in California.

Emission Reduction Calculation

Baseline NOx Emissions:	6.9 g/bhp-hr
Reduced NOx Emissions:	0 g/bhp-hr
Rated Horsepower:	90 hp
Annual Operating Hours:	1,900 hours
Load Factor:	0.30
% Operated in CA:	100%
(ton/907,200 g):	Converts grams to tons

Baseline Engine
6.9 g/bhp-hr * 90 hp * 1,900 hours/year * 0.30 * 100% * ton/907,200g = 0.39 tons/year

Reduced Engine
0 g/bhp-hr * 90 hp * 1,900 hours/year * 0.30 * 100% * ton/907,200g = 0.0 tons/year

0.39 tons/year – 0.0 tons/year = **0.39 tons/year NOx reduced**

Cost-Effectiveness Calculations
The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (3 percent) used to amortize the project cost over the project life. The incremental capital cost to the equipment owner for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Total cost of new electric forklift:	**=** $ 39,900 + $ 4,000 = $ 43,900
Incremental Capital Cost:	**=** $ 43,900 - $ 35,730 = $ 8,170
Max. Amount Funded:	= $ 8,170
Capital Recovery:	**=** $[(1 + 0.03)^5 (0.03)]/[(1 + 0.03)^5 – 1] = 0.218$
Annualized cost:	= $ 8,170 * 0.218 = $ 1,784/year
Cost-Effectiveness:	**=** ($ 1, 784/year)/(0.39 tons/year) **= $ 4,574/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced and is eligible for an incentive amount of $8,170.

In this example, emission reductions were attainable throughout the entire five-year project life because the proposed CI retrofit control measure will not require an existing forklift whose useful life extends through the end of the five-year project life to retrofit. Additionally, NOx emissions have not been quantified for CI retrofits. In the following example, annual emission reductions are again attainable throughout the entire five-year project life in spite of the proposed implementation of an electric forklift purchase control measure.

Example 2
Calculations for replacement of a propane forklift, based on hours of operation
A forklift owner applies for a Carl Moyer Program grant for the purchase of a new counter balanced sit down rider electric forklift to replace a propane powered ICE forklift. The forklift owner has decided to purchase a new electric forklift instead of purchasing a new propane forklift certified to a 3.0 g/bhp-hr NOx standard. The cost of the new electric forklift is $30,000 (including one battery pack), whereas the cost to buy a new propane forklift is $25,000. The new forklift will operate 1900 hours annually and will operate 100 percent of the time in California.

<u>Emission Reduction Calculation</u>

Baseline NOx Emissions:	3.0 g/bhp-hr
Reduced NOx Emissions:	0 g/bhp-hr
Rated Horsepower:	60 hp
Annual Operating Hours:	1,900 hours
Load Factor:	0.30
% Operated in CA:	100%
(ton/907,200 g):	Converts grams to tons

Baseline Engine
3.0 g/bhp-hr * 60 hp * 1,900 hrs/yr * 0.30 * 100% * ton/907,200g = 0.11 tons/year

Reduced Engine
0 g/bhp-hr * 60 hp * 1,900 hrs/yr * 0.30 * 100% * ton/907,200g) = 0.0 tons/year

0.11 tons/year – 0.0 tons/year = **0.11 tons/year NOx reduced**

<u>Cost-Effectiveness Calculations</u>
The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (3 percent) used to amortize the project cost over the project life. The incremental capital cost to the equipment owner for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Total cost of new electric forklift	= $ 30,000
Incremental Capital Cost	= $ 30,000 - $ 25,000 = $ 5,000
Max. Amount Funded	= $ 5,000
Capital Recovery	**=** $[(1 + 0.03)^5 (0.03)]/[(1 + 0.03)^5 – 1] = 0.218$
Annualized cost	= $ 5,000 * 0.218 = $ 1,090/year
Cost-Effectiveness	= ($ 1,090/year)/(0.11 tons/year) **= $ 9,909/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced and is eligible for an incentive amount of $5,000.

In this example, emission reductions were attainable throughout the entire five-year project life because the proposed CI retrofit control measure will not require an existing forklift whose useful life extends through the end of the five-year project life to retrofit. Additionally, NOx emissions have not been quantified for CI retrofits. In the following example, annual emission reductions are not attainable throughout the entire five-year project life due to the proposed implementation of the ICE forklift retrofit control measure.

Example 3
Calculations for retrofit of a propane forklift, based on hours of operation
A forklift owner applies for a Carl Moyer Program grant to retrofit an existing propane powered ICE forklift. The existing propane forklift has uncontrolled NOx emissions of 10.5 g/bhp-hr. The cost of the retrofit is $5,000. The existing forklift will operate 1900 hours annually for five years and will operate 100 percent of the time in California.

<u>Emission Reduction Calculation</u>

Baseline NOx Emissions:	10.5 g/bhp-hr
Reduced NOx Emissions:	3 g/bhp-hr
Rated Horsepower:	60 hp
Annual Operating Hours:	1,900 hours
Load Factor:	0.30
% Operated in CA:	100%
(ton/907,200 g):	Converts grams to tons

Baseline Engine
10.5 g/bhp-hr * 60 hp * 1,900 hrs/yr * 0.30 * 100% * ton/907,200g = 0.40 tons/year

Reduced Engine
3 g/bhp-hr * 60 hp * 1,900 hrs/yr * 0.30 * 100% * ton/907,200g) = 0.11 tons/year

0.40 tons/year – 0.11 tons/year = **0.29 tons/year NOx reduced**

However, this annual emission reduction is only attainable for the first three years of the project life (assuming a 2003 start date) because the proposed ICE forklift retrofit control measure becomes effective in 2006 and would require the same emissions reductions for the last two years of the project life. The annualized emission reductions for this example are thus:

(3 years/5 year project life) *0.29 ton/year NOx reduced = 0.174 tons/year NOx reduced

<u>Cost-Effectiveness Calculations</u>
The annualized cost is based on the portion of incremental project costs funded by the Carl Moyer Program, the expected life of the project (5 years at a minimum), and the interest rate (3 percent) used to amortize the project cost over the project life. The incremental capital cost to the equipment owner for this purchase and the maximum amount that could be funded through the Carl Moyer Program fund are determined as follows:

Total cost of retrofit	= $ 5,000
Incremental Capital Cost	= $ 5,000
Max. Amount Funded	= $ 5,000
Capital Recovery	**=** $[(1 + 0.03)^5 (0.03)]/[(1 + 0.03)^5 – 1] = 0.218$
Annualized cost	= $ 5,000 * 0.218 = $ 1,090/year
Cost-Effectiveness	= ($ 1,090/year)/(0.174 tons/year) **= $ 6,264/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced and is eligible for an incentive amount of $5,000.

<u>Sample Application</u>

In order to qualify for incentive funds, districts will make applications available and solicit bids for reduced-emission projects from forklift operators. A sample application form is included in Appendix G. The applicant must provide at least the following information, as listed in Table 7.6a - Electric Replacement and Table 7.6b - ICE Retrofit on the following pages.

Table 7.6a. Minimum Application Information Electric Forklift Replacement Projects.

1. Air District: 2. Applicant Demographics Company Name: Business Type: Mailing Address: Physical Address: Contact Number: Contact Name/Title: 3. Project Description Project Name: Engine Function: VIN or Serial Number: Is the electric forklift replacing an older non-electric forklift, Will the forklift be part of an operation or facility, or facility expansion, or for brand new facility operations Maximum rated lift capacity (lbs) **4.** Application: (Repower, Retrofit or New) 5. NOx Emissions Reductions Baseline NOx Emissions Factor (g/bhp-hr): NOx Conversion Factor Used: Reduced NOx Emissions Factor (g/bhp-hr): Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions: 6. Does the applicant rent or lease forklifts to others? 7. Cost of forklift (including 1 battery pack) 8. Cost of charging equipment:	9. Cost of the Base Engine (non-electric): 10. Cost of the Certified Engine: 11. Annual Hours of Operation: 12. Percent Operated in California: Project Life (years): 13. ICE Forklift Being Replaced (if an existing business) Horsepower Rating: Manufacturer: Model: Year: 14. New Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year: Manufacturer and model number of new forklift: Type of forklift purchases: 15. PM Emissions Reductions Baseline PM Emissions Factor (g/bhp-hr): PM Conversion Factor Used: Reduced PM Emissions Factor (g/bhp-hr): Estimated Annual PM Emissions Reductions: Estimated Lifetime PM Emissions Reductions: 16. District Incentive Grant Requested:

Table 7.6b. Minimum Application Information ICE Forklift Retrofit Projects.

1. Air District: 2. Applicant Demographics Company Name: Business Type: Mailing Address: Physical Address: Contact Number: Contact Name/Title: 3. Project Description Project Name: Engine Function: VIN or Serial Number: Maximum rated lift capacity (lbs) 4. Application: (Retrofit) **5.** NOx Emissions Reductions Baseline NOx Emissions Factor (g/bhp-hr): NOx Conversion Factor Used: Reduced NOx Emissions Factor (g/bhp-hr): Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions:	**6.** PM Emissions Reductions Baseline PM Emissions Factor (g/bhp-hr): PM Conversion Factor Used: Reduced PM Emissions Factor (g/bhp-hr): Estimated Annual PM Emissions Reductions: Estimated Lifetime PM Emissions Reductions: **7.** Does the applicant rent or lease forklifts to others? **8.** Cost of retrofit: Project Life (years): 9. Cost of the Base Engine: 10. Cost of Certified Engine: 11. Annual Hours of Operation: 12. Percent Operated in California: 13. District Incentive Grant Requested:

Reporting and Monitoring

The district has the authority to conduct periodic checks or solicit operating records from any applicant that has received CMP funds for new electric forklift projects or ICE retrofit projects. This is to ensure that the equipment is operated as stated in the program application. Forklift owners participating in the CMP are required to keep appropriate records throughout the life of the funded project. Records must contain, at a minimum, total hours operated, and maintenance and repair information. For electric forklift projects, records must additionally contain information on the amount of electricity used, the type and characteristic of charging equipment used, and information pertaining to what was done with the ICE forklift that was replaced. All records must be retained and updated throughout the project life and made available at the request of the district. Districts could may conduct a scrapping program to ensure that the ICE forklifts being replaced are removed from the inventory.

For electric forklift projects, districts are also encouraged to closely review applications from applicants who own multiple facilities (i.e., own a chain of facilities) to determine that the applicant demonstrates a significant increase in electric forklift purchases at the new facility versus its existing facilities. Applicants with multiple facilities that are applying for funding at a new facility (additional outlet) would need to provide the district with adequate documentation on the history of forklift purchases for its California facilities. For example, Applicant X owns three outlets in California and is opening a fourth outlet. Applicant X is applying for Carl Moyer Program funding for new electric forklifts at that fourth outlet. Applicant X would need to provide its forklift purchasing history (i.e., the amount of electric forklifts versus ICE forklifts at each facility) to the district. In this example, the district reviews the historical purchasing data and determines that at facilities 1, 2 and 3 there are 80 percent electric forklifts and 20 percent ICE forklifts. Based on this data, the district would need to review the application for the new facility to determine that the applicant is demonstrating a significant increase in electric purchases over ICE purchases (i.e., 90% electric to 10 % ICE forklifts) at this facility versus its existing facilities. If the applicant demonstrates a significant increase in electric forklift purchases vis-a-vis ICE purchases over its other facilities, then the project could be funded, provided all other criteria are met.

Chapter Eight
AIRPORT GROUND SUPPORT EQUIPMENT

This chapter presents the project criteria under the CMP for airport ground support equipment (GSE). It also contains a brief overview of the different types of equipment, current emission standards, available control technology, potential incentive projects eligible for funding, and emission reduction calculation and cost-effectiveness calculation methodologies.

INTRODUCTION

Airport vehicles and ground support equipment are used to transport passengers as well as baggage and freight, to support maintenance and repair functions, and to provide power to various service functions. Vehicles and equipment at airports fall into two broad categories. Land-side vehicles and equipment are used on the passenger/entry side of the airport. Air-side vehicles are used principally (at least half of the time) on the tarmac. For the purposes of the CMP, this airport GSE chapter is only to be used to evaluate air-side equipment. Land-side vehicles and equipment may be considered under the on and off-road vehicles and equipment project criteria of the CMP.

Airport GSE includes aircraft pushback tugs, baggage and cargo tugs, carts, forklifts and lifts, ground power units, air conditioning units, belt loaders, and other equipment. It also includes vehicles such as light duty trucks that are used for airplane maintenance and fueling on the air-side of airport operations.

Most GSE in California have IC engines. Electric GSE has zero exhaust emissions and thus can greatly reduce NOx emissions. Electric GSE is commercially available from a number of manufacturers, and interest in the use of electric equipment is increasing. Currently, there are no federal or California regulations that require the use of electric GSE. Less than 10% of the GSE used at airports in California is estimated to be electric.

There are airports, however, with a very high percentage of electric GSE. For example, Denver International Airport was built within the last ten years, and was designed for all electric GSE. Also, Logan International Airport in Boston has made considerable progress in switching from ICE equipment to electric GSE equipment.

GROUND SUPPORT EQUIPMENT AND EMISSIONS

GSE is used the moment an aircraft lands and until it takes off. GSE is used for tasks such as towing, powering, and servicing. There is great diversity in the type of equipment used, as well as in the variety of engines that power GSE. The table below presents commonly used types of GSE and their estimated population in California. These estimates are based on ARB's off-road emissions inventory. They do not include updated estimates for the South Coast Air Basin currently under development as part of the airport consultative process.

Table 8.1. Airport GSE Population in California 1995.

Equipment Type	Diesel	Gasoline	LPG/CNG	Statewide Total
Baggage Tug	440	646	89	1,175
Belt Loader	172	304	19	495
Forklifts, lifts & cargo loaders	197	319	214	730
Ground Power Unit	228	71	0	299
Aircraft Tug (narrow & wide body)	214	60	0	274
Airstart Unit	70	0	0	70
Air Conditioner	22	0	0	22
Deicer	0	29	0	29
Cart & Lavatory Cart	0	22	0	22
Fuel Trucks	23	56	26	105
Utility Trucks (lavatory, maintenance, water & service)	20	356	31	407
Bobtail	0	92	2	94
Other	17	160	17	194
TOTAL	1,403	2,115	398	3,916

Definitions

- ***Baggage Tugs*** (or Tractors) transport luggage or cargo between aircraft and terminals.
- ***Belt Loaders*** are a self-propelled conveyer belt that moves baggage and cargo between the ground and the airport.
- ***Forklifts, Lifts, and Cargo Loaders*** include equipment for lifting and loading cargo.
- ***Ground Power Units (GPUs)*** provide electricity to parked aircraft.
- ***Aircraft Tugs*** (pushback tractors) tow aircraft in areas where aircraft cannot use their own engines for motion. These are generally the areas between the taxiway and the terminal and between the terminal and the maintenance base.
- ***Air Start Units*** are trailer or truck-mounted compressors that provide air for starting up the aircraft’s main engines.
- ***Air Conditioning Units*** are trailer or truck mounted compressors that deliver air through a hose to parked aircraft for cabin ventilation and engine cooling.
- ***Deicers*** are trailers equipped with tank, pump, hose, and spray gun to transport and spray deicing fluid on aircraft.
- ***Lavatory carts*** are used to service aircraft lavatories. Other types of carts can be used to transport equipment and personnel.

- ***Fuel Trucks, Utility Trucks, Maintenance, Water and Service Trucks*** are used on the air-side of the airport for many diverse tasks.

- ***Bobtail Tractors*** are on-road trucks modified to tow trailers and equipment

Airport GSE can be owned by airlines, airports, cargo handlers, mail and parcel companies or management companies. Most airlines own or maintain the GSE they use, or have full service leasing from equipment management companies. Airports usually own the buildings and other stationary infrastructure on site and lease them to the airlines. The installation and cost of improvements, including electric equipment and vehicle infrastructure, are usually subject to the approval of the airport's property management. Costs can either be borne by the airport or passed on to the airlines. There is also a growing trend for airports to own the ground power units and charge the airlines for the time of usage.

As indicated in Table 8.1, there were an estimated 3,916 pieces of GSE operating in California in 1995. Table 8.2 lists 1995 and 2010 estimated NOx emissions from airport GSE in the South Coast Air Basin and statewide.

Table 8.2. Baseline NOx Emissions Airport GSE.

Location	Population	NOx Emissions (tons/day)	
		1995	**2010**
South Coast Air Basin	2,064	2.7	1.8
Statewide	3,916	5.0	3.2

<u>Emissions Standards</u>
U.S.EPA and ARB have adopted emission standards applicable to new (off-road) GSE equipment powered by IC engines to be phased in. GSE’s are regulated under ARB and U.S.EPA's equivalent emission standards for off-road equipment. Internal combustion engine GSE can either be powered by CI (diesel) engines or by SI engines (gasoline, CNG, or propane fuel). There are separate emission standards for LSI engines and CI engines. The reader is referred to Chapter 7 for discussions on existing and proposed standards for LSI off-road engines. Specifically, Table 7.3a illustrates the current standards while Table 7.3b lists the proposed new California standards to harmonize with adopted federal standards for 2007.

ARB has adopted emission standards for off-road diesel engines rated at 175 hp and larger. The U.S.EPA has adopted NOx emission standards for off-road diesel engines rated at 50 hp and larger. The combination of ARB and U.S.EPA emission standards means that all of today’s new off-road diesel engines, including GSE engines, 50 hp and greater have to be certified to meet a NOx+NMHC emission standard of 5.6 g/bhp-hr or lower depending on hp rating. The reader is referred to Chapter 3 for presentation and discussion of emission standard of off-road engines. Specifically, Table 3.1 illustrates the applicable standards for all off-road engines.

In contrast, as discussed earlier, there are currently no regulations requiring the use of electric GSE at airports. Measure M15 in the 1994 SIP for ozone called for the U.S.EPA to set new standards for aircraft engines. The SIP superseded U.S.EPA's Federal Implementation Plan (FIP), which did call for electric GSE at airports. Consequently, these activities led ARB, U.S.EPA, the SCAQMD, the Air Transport Association (ATA), and other stakeholders in the South Coast Air Basin to participate in a Public Consultative Process that includes negotiations to develop approaches (besides aircraft emission standards) for reducing emissions from airport activities.

In 2002, the ARB and several participating airlines entered into an Memorandum of Understanding (MOU) aimed at introducing cleaner GSE's, with an emphasis on electric GSE's, into the South Coast Air Basin. Under the agreement, all major airlines operating at five airports in the South Coast Air Basin (LAX, Ontario, Orange County, Burbank, and Long Beach) would begin to incorporate lower-emission GSE's into their fleets. GSE retrofits and electric GSE's purchases that, in any way, help fulfill this MOU obligation are not eligible for funding under the CMP.

CONTROL STRATEGIES

A cost-effective strategy to reduce emissions involves the replacement of GSE powered by an IC engine with electric equipment, which has no exhaust emissions. Electric GSE is commercially available for a number of equipment types, including belt loaders, baggage tractors, aircraft tugs, lifts, and GPU's. Several airlines and airports have conducted electric GSE demonstration programs and fleet conversion programs. Much of the experience to date with electric equipment has been positive. In addition to air quality benefits, users have found that electric equipment is more "task specific" than ICE equipment. In addition, electric equipment often includes ergonomic features and users have reported finding that it "rides better" than equivalent diesel equipment. However, the higher capital cost of electric equipment continues to prevented its widespread. Further discussion of control strategies was reported to ARB by Arcadis Geraghty & Miller (1999) [ARB 1999].

The CMP will fund the replacement of ICE GSE with comparable electric equipment in California if this equipment is not subject to any existing or planned MOU obligation, funded through another incentive program, or used to generate credits on any type. The most promising categories are those where electric equipment has been used and demonstrated and is readily available from commercial vendors. This includes electric baggage tugs, belt loaders, and aircraft tugs. These equipment categories also represent a significant portion of the statewide GSE population and have some of the highest average annual hours of usage. Replacement of ICE equipment with comparable electric equipment would yield significant NOx emission benefits. Therefore, the CMP guidelines continue to target these categories. Other promising projects include lifts and cargo loaders. Carts, lavatory carts and airstart units each represent a smaller fraction of the GSE equipment inventory. Fuel, utility, water, and service trucks are not covered under the current airport GSE guidelines, but may be considered under the on-road category.

PROJECT CRITERIA

The primary focus of the CMP continues to be to achieve emission reductions from off-road engines and equipment operating in California as early and as cost-effectively as possible. The project criteria designed to ensure that the emission reductions expected through the deployment of electric GSE's are real and quantifiable are retained in the current CMP guideline revisions. All projects 1) are subject to the C/E criterion of $13,600 per ton of NOx reduced, 2) must operate for at least five years, and 3) At a minimum, 75% of the hours of operation must occur in California. Airport GSE projects must meet the general project criteria and the specific airport GSE project criteria provided below.

- Existing ICE equipment must be replaced with new electric equipment.

- Eligible equipment includes the following: belt loaders, baggage tugs or tractors, forklifts, lifts, cargo loaders, ground power units, or aircraft tugs. Other GSE equipment will be evaluated on a case-by-case basis.

- Equipment must be purchased for use at a commercial (passenger) airport in California.

- Equipment purchased for use at a military airport will be considered on a case-by-case basis. The equipment must not be covered by any existing regulations or permit requirements, and the emission reductions must be surplus to any credit banking programs.

- Equipment must be purchased by the business or organization that will be operating the equipment such as airports and commercial (passenger) airline companies.

- Purchases by airline service companies or ground handlers are eligible if they provide documentation (such as written contracts or other binding agreements) specifying that they will operate the equipment at a passenger airport not excluded under the CMP for a minimum of five years.

- The existing ICE equipment, which is being replaced must have an engine rated at 50 hp or greater (which is equivalent to an electric motor 37 kilowatts or greater).

- NOx reductions obtained through this program must not be required by any regulation, memoranda of understanding or agreement, air quality permit requirement, California Environmental Quality Act (CEQA) or other offset agreement, or any other legally binding agreement.

- Projects at airports in the South Coast Air Basin (LAX, Ontario, Orange County, Burbank, and Long Beach) are not eligible.

- Leased or rented new or used equipment is not eligible.

- The minimum acceptable project life for calculating emission benefits from GSE projects is 5 years. It is noted that 20 years may be a typical GSE engine life. In this case, project life reflects the period over which the CMP buys emission credits.

Sample Application

In order to qualify for incentive funds, districts will make applications available and solicit bids for reduced-emission projects from GSE equipment operators. A sample application form is included in the appendix. The applicant must provide at least the following information listed in Table 8.5 below.

Table 8.5. Minimum Application Information GSE Projects.

1. Air District: 2. Applicant Demographics Company Name: Business Type: Mailing Address: Location Address: Contact Number: Equipment Operator: (airport, airline, equipment management company, other) 3. Project Description Project Name: Engine Function: VIN or Serial Number: Airport where equipment operated: Equipment Function: (replacement for an existing equipment, fleet expansion, other) 4. Application: (Repower, Retrofit or New) 5. Annual Hours of Operation: 6. Percent Operated in California: 7. Project Life (years): 8. Existing ICE Equipment Being Replaced (if an existing business) Horsepower Rating: Manufacturer: Model: Year: Fuel Type	9. New Equipment Information Horsepower Rating: Make: Model: Year: Manufacturer Type of New Equipment purchases Number of New Equipment purchased: 10. NOX Emissions Reductions Baseline NOx Emissions Factor (g/bhp-hr): NOx Conversion Factor Used: Reduced NOx Emissions Factor (g/bhp-hr): Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions: 11. Cost of New Equipment (including 1 battery pack) 12. Cost ($) of the Base Engine: 13. Cost ($) of Certified LEV Engine: 14. PM Emissions Reductions Baseline PM Emissions Factor (g/bhp-hr): PM Conversion Factor Used: Reduced PM Emissions Factor (g/bhp-hr): Estimated Annual PM Emissions Reductions: Estimated Lifetime PM Emissions Reductions: 15. District Incentive Grant Requested:

EMISSION REDUCTION AND COST-EFFECTIVENESS

The NOx emission reduction benefit shall be determined using equipment annual hours of operation. Annual NOx emission reductions are determined by multiplying the difference in the NOx emission levels of electric and ICE equipment, the engine load factor, and the expected hour of operation. Load factor is an indication of the work requirement for the engine operating over a particular a duty cycle. Load factor is typically given as a fraction of the engine hp rating. Default LF's are illustrated in Table 8.6. An applicant may request to use a different LF than the indicated default value with proper documentation. If the applicant does not have records of actual hours of equipment operation, the default values given in Table 8.6 may be used. In addition, baseline NOx emissions for pre-2001 ICE equipment are provided in Table 8.7. For post-2001 engines used in existing GSE equipment, the reader is referred to Chapter 7, Table 7.5. The information illustrated below is contained ARB emission inventory models. The reader is referred to Chapter 3, Table 3.4 for baseline emission factors for diesel-fuel engines.

Table 8.6. Default Load Factors and Annual Operating Hours.

Equipment	Horsepower	Load Factor	Annual Hours
Belt Loader	51-120	0.50	810
Baggage Tug	130-175	0.55	876
Cargo Loaders	51-120	0.50	719
A/C Tugs wide body	250-500	0.80	515
A/C Tugs narrow body	121-175	0.80	551
Lifts	51-120	0.50	376
Ground Power Units	120-175	0.75	796

Table 8.7. Default Baseline Emission Factors for pre-2001 GSE Equipment.

Horsepower Range	Fuel Type	Baseline NOx Emissions (g/bhp-hr)
>50	Propane	10.5
51-120	Gasoline	11.8
121-175	Gasoline	12.9

The portion of the cost for a GSE project to be funded through the CMP is the difference between the total cost of purchasing new electric equipment and the cost of buying "conventional" replacement equipment. Only the amount of money provided by the CMP and any local district match funds shall be used in the C/E calculations. The one-time incentive grant amount is to be amortized over the expected project life (at least five years) with a discount rate of 3%. The reader is referred to Chapter 2 for discussion of the updated discount rate. The amortization formula (given below) yields a capital recovery factor, when multiplied with the initial capital cost, gives the annual cost of a project over its expected lifetime.

$$\textit{Capital Recovery Factor (CRF)} = [(1 + i)^n (i)] / [(1 + i)^n - 1]$$

where, i = discount rate (3%)
n = project life (at least five years)

Example 1
Calculations for replacement of a diesel baggage tug based on hours of operation
A passenger airline in Sacramento applies for a CMP grant for the purchase of four new electric baggage tugs to replace four diesel baggage tugs currently in the fleet. The

airline has decided to purchase the electric baggage tugs instead of purchasing new diesel baggage tugs certified to a 4.9 g/bhp-hr NOx+NMHC standard. The cost of a new electric baggage tug is $24,000 (each) and the cost to buy a new diesel baggage tug is $19,000 (each). The new baggage tugs each will operate 876 hours annually (each) and will operate 100 percent of the time in California.

Emission Reduction Calculation

Baseline NOx+NMHC Emissions:	4.9 g/bhp-hr (new diesel baggage tug)
Baseline NOx Emissin:	4.9*0.95=4.7 g/bhp-hr
Reduced NOx Emissions:	0 g/bhp-hr (new electric baggage tug)
Horsepower Rating:	100 hp
Load Factor:	0.55
Annual Operating Hours:	876 hours
% Operated in CA:	100%
Conversion factor:	1 ton = 907,200 g

Baseline Engine
4.7 g/bhp-hr *100 hp * 0.55 *876 hrs/yr * 4 baggage tugs * 100% * ton/907,200 g = 1 ton/yr

Replacement Engine
Electric bag tug = 0.0 g/bhp-hr = 0.0 tons/year

1 tons/year – 0.0 tons/year = **1 tons/year NOx emissions reduced**

Cost-Effectiveness Calculations

The annualized cost is based on the portion of incremental project costs funded by the CMP, the expected life of the project (20 years), and the interest rate (3%) used to amortize the project cost over the project life. The incremental capital cost to the equipment owner for this purchase and the maximum amount that could be funded through the CMP are determined as follows:

Total cost of new electric baggage tug	**=** $ 24,000 x 4 = $ 96,000
Cost of new diesel baggage tug	**=** $ 19,000 x 4 = $ 76,000
Incremental Capital Cost	**=** $ 96,000 - $ 76,000 = $ 20,000
Max. Amount Funded	**=** $ 20,000
Capital Recovery	**=** $[(1 + 0.03)^{20} (0.03)]/[(1 + 0.03)^{20} – 1] = 0.067$
Annualized cost	**=** $ 20,000 * 0.067 = $ 1,340/year
Cost-Effectiveness	**=** ($ 1,340/year)/(1 tons/year) **= $1,340/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced and is eligible for funding.

Example 2

Calculations for replacement of a diesel belt loader based on hours of operation

An airline company that operates at the Fresno airport applies for a CMP grant for the purchase of a new electric belt loader to replace a diesel belt loader in their existing fleet. The new electric belt loader will be used for five years at the Fresno airport. The airport has decided to purchase a new electric belt loader instead of purchasing a new diesel belt loader. The cost of the new electric belt loader is $30,000, whereas the cost to buy a new diesel belt loader is $27,000. The new belt loader will operate 810 hours annually and will operate 100 percent of the time in California.

Emission Reduction Calculation

Baseline NOx+NMHC Emissions:	5.6 g/bhp-hr (new diesel belt loader)
Baseline NOx Emission:	5.6*0.95=5.3 g/bhp-hr
Replacement NOx Emissions:	0 g/bhp-hr (new electric belt loader)
Rated Horsepower:	60 hp
Annual Operating Hours:	810 hours
Load Factor:	0.55
% Operated in CA:	100%
Conversion factor:	1 ton=907,200 g

Baseline Engine
5.3 g/bhp-hr * 60 hp * 0.55 * 810 hours/year * 100% * ton/907,200 g = 0.16 tons/year

Reduced Engine
Electric belt loader 0.0 g/bhp-hr = 0.0 tons/year

0.16 tons/year – 0.0 tons/year = **0.16 tons/year of NOx emissions reduced**

Cost-Effectiveness Calculations
The annualized cost is based on the incremental project costs funded by the CMP, the expected life of the project (5 years at a minimum), and the interest rate (3%) used to amortize the project cost over the project life. The incremental capital cost to the equipment owner for this purchase and the maximum amount that could be funded through the CMP are determined as follows:

Total cost of new electric belt loader	**=** $ 30,000
Incremental Capital Cost	**=** $ 30,000 - $ 27,000 = $ 3,000
Max. Amount Funded	**=** $ 3,000
Capital Recovery	**=** $[(1 + 0.03)^5 (0.03)]/[(1 + 0.03)^5 – 1] = 0.218$
Annualized cost	**=** $ 3,000 * 0.218 = $ 654/year
Cost-Effectiveness	**=** ($ 654/year)/(0.16 tons/year) **= $ 4,088/ton**

The project meets the cost-effectiveness limit of $13,600 per ton NOx reduced and is eligible for an incentive amount of $3,000.

Reporting and Monitoring
ARB and participating districts have the authority to conduct periodic checks or solicit operating records from the applicant that has received CMP funds for new electric GSE projects. This is to ensure that the equipment is operated as stated in the program application. CMP grantees are required to keep appropriate records during the life of the project funded. Records must contain, at a minimum, total hours operation, amount of electricity used, and maintenance and repair information. Records must be retained and updated throughout the project life and made available upon request by ARB of the district.

Chapter Nine
PARTICULATE MATTER EMISSION REDUCTION REQUIREMENTS AND GOALS

This chapter describes the particulate matter (PM) baseline levels and calculation methodology. This chapter also contains a brief overview of available control technologies, the PM target and requirements recommended by the CMP Advisory Board and established by the Board in these revisions, PM emissions reduction calculations, and examples for calculating PM emission reductions.

INTRODUCTION

Diesel PM continues to be a serious public health concern. Diesel PM, like ozone, has been linked to a range of serious negative health effects including an increase in respiratory disease, lung damage, cancer, and premature death. Fine diesel particles are deposited deep in the lungs and can result in increased hospital admissions and emergency room visits; increased respiratory symptoms and disease; decreased lung function, particularly in children and individuals with asthma; alterations in lung tissue and respiratory tract defense mechanisms; and premature death. On August 27, 1998, after extensive scientific review and public hearing, the ARB formally identified particulate emissions from diesel-fueled engines as a toxic air contaminant (TAC).

The CMP was originally envisioned to help California meet the NOx emission reduction commitments in measure M4 of the 1994 SIP for ozone. Although the focus of the program continues to be near-term NOx reductions, some of the technologies, such as electric motors and alternative fueled engines, funded by this program also reduce PM emissions. Even without specific requirements for PM emission reductions, the CMP has achieved approximately 100 pounds per day of PM reductions from projects funded in its first year (FY 1998/1999) [ARB March 2002]. Scientific evidence continues to suggest additional adverse health effects associated with the risk of exposure to diesel PM emissions. Thus, PM reductions achieved by an incentive program such as the CMP have become critical.

<u>Advisory Board Recommendations</u>

Section 44297 of the Health and Safety Code created a thirteen-member Advisory Board designated with the responsibility for oversight of the CMP in its early stages. The Advisory Board was asked to provide the Legislature and the Governor a report containing recommendations for the long-term vision of the CMP. The Advisory Board released their report to the Governor and Legislature in March of 2000 [ADVISORY BOARD 2000]. In that report, the Advisory Board recognized that diesel PM is a serious public health concern and PM reductions are necessary throughout California. The Advisory Board established a PM reduction target for the statewide program and a PM reduction requirement for areas designated as serious non-attainment for the federal PM10 (particulate matter less than 10 microns) standard. As a result, ARB incorporated in the CMP guidelines information related to PM emissions to aid in the assessment of PM emission reductions benefits from CMP funded projects.

EMISSIONS INVENTORY AND STANDARDS

Statewide NOx and PM10 emissions from select categories of heavy-duty engines are shown in Table 9.1. According to the 2001 inventory, PM emissions statewide from all mobile sources are approximately 123 tons per day. Heavy-duty mobile source engines account for about 65% mobile source emissions of PM statewide. Light and medium-duty vehicles account for about 30%. Currently two air districts, San Joaquin Valley APCD and SCAQMD exceed federal PM10 ambient air quality standards. In general, most districts do not attain California's more stringent state PM standards, leaving millions of Californians exposed to unhealthy levels of ambient PM.

Table 9.1. Statewide Emissions from Selected Heavy-Duty Engine Categories.

Source Category	**Current PM_{10}**	**2010 PM_{10}**
On-Road Heavy-Duty Vehicle [a]	18	14
Off-Road Equipment [b]	32	25
Locomotive	3	3
Marine	9	10
Total	62	52

a) Emissions from gasoline and diesel trucks and buses. Emissions based on EMFAC2002 model, corrected to account for 2004 and 2007 standards and off-cycle emissions.
b) 2001 emissions from off-road equipment, including equipment less than 50 hp.

Emission Standards

The PM emission factors listed in Tables 9.2, 9.3, and 9.4 represent the EMFAC2002 zero-mile emission factors for diesel-powered medium HDV's, heavy HDV'ss, and urban buses, respectively. Emission factors for school buses and neighborhood refuse are based on GVWR. For alternative-fueled urban transit buses, existing in-use test data shows that PM in-use emissions are 30% to 50% (i.e., a natural gas bus certified to the 0.03 g/bhp-hr PM standard) than for a diesel bus engine certified to the 0.01 g/bhp-hr PM standard. Thus, alternative-fueled urban transit bus projects can use a 0.025 g/mile PM emission factor.

Table 9.5 provides model year emission factors from the adopted OFFROAD emission inventory model by horsepower group. These off-road emission factors can be used for stationary agricultural irrigation pumps and harbor vessels with medium speed diesel engines. Table 4.2 presented in Chapter 4 lists the PM emission factors for locomotives based on U.S.EPA standards. Tier 0 emission factors should be used for uncontrolled engines.

As discussed in Chapters 2 and 3, the use of California's diesel fuel since 1993 (0.05 percent sulfur content by weight and 10 percent aromatic content by volume) would result in additional NOx and PM emissions from diesel engines compared to the base emission rates. Base emission rates for diesel engines, as embodied in EMFAC2002 and OFFROAD and presented in the above tables, were derived from test data using either federal diesel fuel (0.05 percent sulfur content by weight) or pre-1993 diesel fuel. Thus, a fuel adjustment factor needs to be applied to the base emission rate to more

Table 9.2. PM Emission factors for Medium Heavy-Duty Vehicles
14,001 – 33,000 lbs GVWR.

Model Year	g/mile
Pre - 1984	1.1
1984 - 1986	1.0
1987 - 1990	0.7
1991 - 1993	0.4
1994 - 1997	0.3
1998 - 2002	0.2
2003 - 2006	0.3
2007+	0.03

Table 9.3. PM Emission factors for Heavy Heavy-Duty Vehicles 33,000 + lbs GVWR.

Model Year	g/mile
Pre - 1975	2.0
1975 - 1983	1.8
1984 - 1986	1.2
1987 - 1990	0.8
1991 - 1993	0.5
1994 - 1998	0.3
1999 - 2002	0.2
2003 – 2006	0.3
2007 +	0.03

Table 9.4. PM Emission factors for Urban Buses.

Model Year	g/mile
Pre - 1987	1.3
1987 - 1990	1.2
1991 - 1993	1.1
1994 - 1995	1.4
1996 - 1998	1.7
1999 - 2002	0.6
2003+	0.1

accurately reflect the emissions from diesel engines when those engines are operated using California diesel fuel. Table 9.6 shows the PM fuel adjustment factors to be used for diesel engines.

CONTROL TECHNOLOGIES

A retrofit involves a hardware modification to an existing engine to reduce its emissions from the standards to which it was originally certified. A variety of diesel oxidation catalysts (DOC) and diesel particulate filter (DPF) or traps have been developed for PM emission control. The ARB has recently verified DOC and DPF systems for HD diesel vehicles. DOC's have control efficiencies on the order of 25% while traps can achieve PM reductions of 85% or better. In general, DOC's are add-on install-and-forget

Table 9.5. PM Emission factors for Heavy-Duty Off-Road Diesel Engines.

Horsepower	Model Year	g/bhp-hr
50 - 120	Pre - 1988	0.84
	1988 - 2003	0.69
	2004	0.39
	2005	0.29
	2006 - 2007	0.24
	2008 +	0.19
121 - 175	Pre - 1970	0.77
	1970 - 1971	0.66
	1972 - 1987	0.55
	1988 - 2002	0.38
	2003	0.24
	2004	0.19
	2005 – 2006	0.16
	2007 +	0.14
176 - 250	Pre - 1970	0.77
	1970 - 1971	0.66
	1972 - 1987	0.55
	1988 - 1995	0.38
	1996 - 2002	0.15
	2003	0.12
	2004 +	0.11
251 - 500	Pre - 1970	0.74
	1970 - 1971	0.63
	1972 - 1987	0.53
	1988 - 1995	0.38
	1996 - 2000	0.15
	2001	0.12
	2002 +	0.11
501 - 750	Pre - 1970	0.74
	1970 - 1971	0.63
	1972 - 1987	0.53
	1988 – 1995	0.38
	1996 – 2001	0.15
	2002	0.12
	2003 +	0.11
750+	Pre - 1970	0.74
	1970 - 1971	0.63
	1972 - 1987	0.53
	1988 – 1999	0.38
	2000 – 2005	0.15
	2006	0.12
	2007 +	0.11

Table 9.6 Fuel Correction Factors (Diesel Engines)

Engine Category	Model Year	PM
On-Road	Pre – 1991	0.80
	1991-1993	0.69
	1994+	0.90
Off-Road	Pre-Tier I	0.80
	Tier I +	0.90

devices designed for application on pre-1994 model year engines. PM filters are also add-on devices, but require some means of regeneration to dispose of the collected PM. Failure to regenerate or burn off PM can plug the filter, resulting in excessive backpressure on the engine. In addition, cleaning of residual ash deposits is necessary. Excessive PM on the filter can burn, but may result in overheat and filter damage. For this reason, DPF's are retrofits typical for application on 1994 and newer engines. In most applications, the exhaust temperature of a diesel engine is not sufficient for filter regeneration.

Catalyzed DPF's are passive filters that achieve regeneration without external input of energy. In this system, a catalyst induces ignition at typical exhaust temperature encountered during normal operation. The catalyst material is incorporated into the filter system. In addition, a catalyst can be fuel-borne. In several European countries, catalyst-based DPF's have been installed on numerous HDV's and successful demonstrations have been reported extensively in the technical literature. In the U.S., various demonstrations of catalyst-based DPF's have taken place or are in progress. Progressively, fleets and HDV operators are starting to procure these retrofit system not only to comply with recently adopted regulations, but also to voluntarily address potential issues associated with the risk of exposure to diesel exhaust PM. In California, diesel-fueled school buses, transit buses, line-haul trucks, and tanker trucks have been retrofitted with catalyzed DPFs as part of a number of demonstration programs.

PM REDUCTION TARGETS AND REQUIREMENTS

Through a public process, the Advisory Board established the following PM reduction target and requirement:

- A 25% PM emissions reduction target for all participating districts on a statewide program- basis, except for those in serious non-attainment of PM 10 standards.

- A 25% PM emissions reduction requirement for districts designated as serious non-attainment of PM10 federal standards. Currently, SJVAPCD and SCAQMD are the only two districts affected by the proposed requirement. They must reduce PM emissions by 25% district-wide on a CMP program basis (not on a project basis).

EMISSIONS REDUCTIONS

The program C/E continues to be based on NOx emission reductions. PM emission reductions are determined in a similar fashion to NOx reductions. If NOx reductions are based on annual miles traveled, then PM reductions must also be based on annual miles traveled. It is noted that NOx and PM emissions, both for uncontrolled engines and for emission-certified engines, are not the same. Thus, the reader is urged to exercise caution and use the appropriate emission factors. Baseline PM emission factors were introduced in Tables 9.2 to 9.5 above.

PM reductions on a program basis for the participating districts will be considered to determine compliance with PM reduction goals and requirements.

In addition, a new CMP provision involves the ability of participating districts to use funds under their authority for projects that focus exclusively on PM emission reductions. Funds used for PM-only projects can be use to meet matching fund requirements established by the CMP. Possible projects include retrofits for HD diesel trucks or off-road diesel equipment with ARB verified after-treatment systems. Participating districts without a match requirement cannot use their minimum allocations to fund PM reduction projects. In addition, the C/E criterion of $13,600/ ton of NOx reduced required for all CMP projects does not apply for projects focused on PM emission reductions only. ARB staff will work with districts to develop appropriate cost-effectiveness limits for PM. Districts retain the flexibility to propose appropriate allocations for PM reduction projects and are subject to ARB's concurrence.

Emission Reduction Calculations

In order to incorporate the Advisory Board's PM criteria into the CMP, ARB is providing PM emission factors to calculate PM emission reductions from eligible projects. PM emission reductions are determined in the same manner as NOx emission reductions. ARB determines overall statewide and air district compliance with the PM reduction goals and requirements based on the information provided by the participating districts. ARB retains the authority to make modifications to the program if PM reduction goals and requirements are not on track.

Example 1

Diesel-to-Diesel On-Road Vehicle Repower (Calculations Based on Annual Miles Traveled)

A line haul trucking company proposes to repower a model year 1986 truck with a model year 1991 diesel engine. The truck travels 60,000 miles a year and has a GVWR of 35,000 pounds. The applicant used the vehicle's annual miles traveled to determine NOx emissions reductions, and hence, will also use annual miles traveled to calculate PM emissions reductions.

Baseline PM Emissions:	1.2 g/mile
Adjusted Baseline PM Emissions:	(1.2 g/mile)(0.80) = 0.96 g/mile
Reduced PM Emissions:	0.5 g/mile
Adjusted Reduced PM Emissions:	(0.5 g/mile)(0.67) = 0.40 g/mile
Annual Miles Traveled:	60,000 miles
% Operated in CA:	100%
Conversion factor: :	1 lbs = 454 g

Baseline Engine: 0.96 g/mile * 60,000 miles * 100% * lbs/454 g = 127 lbs/year

Reduced Engine: 0.40 g/mile * 60,000 miles * 100% * lbs/454 g = 53 lbs/year

Estimated Annual PM Reductions

127 lbs/year - 53 lbs/year = **74 lbs/year PM emissions reduced**

Example 2
On-Road Diesel-to-CNG Repower (Calculations Based on Annual Miles Traveled)
Consider a transit agency faced with the opportunity of replacing a fleet of diesel-fueled buses with 2003 model year CNG fueled buses. The applicant opts to use the annual miles traveled to determine its NOx emissions reductions. Hence, the vehicle's annual miles traveled will be used to determine the PM emissions reduced

Baseline PM Emissions:	0.1 g/mile
Adjusted Baseline PM Emissions:	(0.1 g/mile)(0.90) = 0.09 g/mile
Reduced PM Emissions:	0.025 g/mile
% Operated in CA:	100%
Annual Miles Traveled:	70,000 miles
Conversion factor: :	1 lbs = 454 g

Baseline Engine: 0.09 g/mile * 70,000 miles * 100% * lbs/454 g = 13.9 lbs/year

Reduced Engine: 0.025 g/mile * 70,000 miles * 100% * lbs/454 g = 3.8 lbs/year

Estimated Annual PM Reductions

13.9 lbs/year – 3.8 lbs/year = **10.1 lbs/year PM emissions reduced**

Example 3
Locomotive Diesel to Diesel Repower (Calculations Based on Annual Fuel Consumption)
A railroad operator, participating in the CMP, repowers a 1975 model year diesel engine of a switcher with a lower emitting Tier 1 engine. The applicant used the annual fuel consumption of 50,000 gallons/year to determine NOx emission reductions, and so will use annual fuel consumption to calculate PM reductions. This locomotive operates 100% of its activity in California. Since federal regulations would require locomotive engines originally manufactured from 1973 to 2001 model years to comply with a Tier 0 PM emission standard of 0.72 g/bhp-hr at the time the of engine rebuild or remanufacture, this value would be used as the baseline emission rate. To qualify for CMP funding, the rebuilt/remanufactured engine will have to comply with, at least, a Tier 1 PM emission standard of 0.54 g/bhp-hr (see Table 4.2 of the locomotives chapter).

Baseline PM Emissions:	0.72 g/bhp-hr
Adjusted Baseline PM Emissions:	(0.72 g/bhp-hr)(0.80) = 0.58 g/bhp-hr
Reduced PM Emissions:	0.54 g/bhp-hr
Adjusted Reduced PM Emissions:	(0.54 g/bhp-hr)(0.90) = 0.49 g/bhp-hr
Energy Consumption Factor:	20.8 bhp-hr/gal
Annual Fuel Consumption:	50,000 gal/year
% Operated in California:	100%

Conversion factor: : 1 lbs = 454 g

Baseline Engine: 0.58 g/bhp-hr * 20.8 bhp-hr/gal * 50,000 gal/yr * 100% * lbs/454 g = 1,329 lbs/yr

Reduced Engine: 0.49 g/bhp-hr * 20.8 bhp-hr/gal * 50,000 gal/yr * 100% * lbs/454 g = 1,122 lbs/yr

Estimated Annual PM Reductions

1,329 lbs/year – 1,122 lbs/year = **207 lbs/year PM emissions reduced**

Example 4

Off-road Diesel-to-Diesel Repower (Calculations Based on Hours of Operation)

A farmer applies for a CMP grant to repower a grape harvester's uncontrolled 1969 diesel engine with at lower NOx and PM emitting model year 2000 remanufactured diesel engine. Both engines are rated at 195 horsepower. If the farmer used 700 annual hours of operation to determine the NOx emissions reductions, then she must also base her PM emission reduction calculation on hours of operation. The project life of the grape harvester is 10 years and it operates 100% in California.

Baseline PM Emissions:	0.77 g/bhp-hr
Adjusted Baseline PM Emissions:	(0.77 g/bhp-hr)(0.80) = 0.62 g/bhp-hr
Reduced PM Emissions:	0.15 g/bhp-hr
Adjusted Reduced PM Emissions:	(0.15 g/bhp-hr)(0.90) = 0.14 g/bhp-hr
Rated Horsepower:	195 hp
Load Factor:	0.65
Annual Operating Hours:	700 hrs
% Operated in California:	100%
Conversion factor: :	1 lbs = 454 g

Baseline Engine
0.62 g/bhp-hr * 195 hp * 0.65 * 700 hrs/year * 100% * lbs/454 g = 121 lbs/year

Reduced Engine
0.14 g/bhp-hr * 195 hp *0.65 * 700 hrs/year * 100% * lbs/454 g = 27 lbs/year

Estimated Annual PM Reductions

121 lbs/year - 27 lbs/year = **94 lbs/year PM emissions reduced**

For areas designated serious non-attainment of the PM10 federal standard, ARB will determine PM emission reductions on a program basis, not a project-to-project basis. Consider the four previous examples as constituting a local district program. These projects yield a total of 385 lbs/year of PM reductions from 1,591 lbs/year of baseline PM emissions. Such a program represents a 24% PM emission reduction and is a little short of the 25% PM emission reduction goal or requirement.

Reporting and Monitoring

Each project category chapter contains monitoring and reporting instructions. PM reporting requirements are included in the minimum information application table of each project category chapter.

Chapter Ten
AUXILIARY POWER UNITS FOR REDUCING IDLING EMISSIONS FROM HEAVY-DUTY VEHICLES

This chapter presents the project criteria for auxiliary power units (APUs) that may be installed on-road HDV's to reduce the vehicle's idling emissions under the CMP. It also contains a brief overview of the engine idling practice of operators of HDV's, NOx emission inventory, available control technology, potential projects eligible for funding, and emission reduction and C/E calculation methodologies. Discussions are also provided for potential consideration of other alternative technologies or strategies that may offer real emission reduction of idling emissions from diesel engines.

EMISSION INVENTORY AND STANDARDS

HDV's are employed in line-haul service carrying goods across the state and throughout the nation. The majority of all HDV's are powered by diesel engines. HDV's employed in line-haul service are typically greater than 33,000 pounds GVWR, are grouped under a Class 8 truck classification, and often accrue very high annual mileage. It is not uncommon for a line-haul truck to accrue 100,000 miles, or more, annually. The engines in these vehicles also operate at idle conditions for a significant amount of time annually, consuming fuel and increasing emissions.

Truck idling practices vary among different fleets, operators, and geographical locations. Two main purposes are to keep the engine and fuel warm, especially in cold weather, and to heat or cool the truck's cab/sleeper compartment. Since HD diesel engines do not operate at optimum efficiency at idle conditions, extended engine idling results in increased emissions and fuel consumption. Although technologies for reducing idling emissions from HD trucks are commercially available, relatively high initial costs have prevented these idling reduction strategies from being more widely utilized.

The CMP can provide incentives to reduce emissions from truck idling by encouraging the purchase and installation of alternative idling reduction technologies. These technologies do not only reduce idling emissions from heavy-duty trucks, but can also result in fuel savings and reduced maintenance costs to truck operators.

<u>Emission Inventory</u>

According to ARB's emission inventory, idling emissions from HD diesel trucks account for approximately 21 tpd of NOx, or about 3% of the total NOx emissions from this sector of vehicles in California. This inventory may underestimate the actual amount of emissions attributable to truck idling since it only accounts for certain defined events of idling that may not encompass the entire envelope of actual idling practices. Idling emissions from individual trucks are significant and the idling emission rate for HD diesel trucks is large. For example, a single HD truck that idles an average of four hours per day emits approximately one-half ton of NOx emissions annually from idling.

Emission Standards
Currently, there are no specific emissions standards to control heavy-duty engine idling operation from HDV trucks. However, some idling restrictions are beginning to emerge. Recently, the ARB approved regulations that restrict idling of school buses based in an effort to decrease the risk of exposure to diesel PM from California school children. In addition, some local government and municipalities have ordinances restricting idling time for some types of vehicles. For the purpose of calculating emission reduction benefits for the CMP, idling emission rates for HD diesel trucks from ARB's inventory model shall be used. Currently, commercially available technology for reducing truck idling emissions makes use of a small off-road engine as the power unit for supplying heating and cooling needs to the truck/cab and, in some cases, electricity to power the truck accessory loads. In these cases, the emission level for the replacement engine corresponds to the emission standards that govern the off-road engine. Table 10.1 lists the existing and future emission standards for small off-road diesel engines that are likely to be employed in APU idling reduction devices. The information is extracted from Table 3.1 in Chapter 3, which illustrates the applicable emission standards for off-road engines.

Table 10.1 . Emission Standards for 2000 -2004 Model Year Off-Road CI Engines
0 – 37 kW (0 - 50 hp).

Pollutants	Power Rating < 8 kW (11 hp)	Power Rating 8 < kW<19 (11<hp<25)	Power Rating 19 < kW<37 (25<hp<50)
HC + NOx	10.5 g/kW-hr (7.8 g/bhp-hr)	9.5 g/kW-hr (7.1 g/bhp-hr)	9.5 g/kW-hr (7.1 g/bhp-hr)
PM	1.0 g/kW-hr (0.75 g/bhp-hr)	0.8 g/kW-hr (0.6 g/bhp-hr)	0.8 g/kW-hr (0.6 g/bhp-hr)

CONTROL TECHNOLOGIES

Auxiliary Power Units
Auxiliary power units (APUs) are self-contained power generating devices, typically packaged with a small IC engine, of 20 hp or less, that can be coupled with a generator and heat exchanger to generate electricity and heat. APU's are usually installed on the truck chassis outside the truck cab to provide power for the truck's accessory loads and to keep the engine warm when the truck is parked. This allows the operator to refrain from idling the truck main engine. The extent of labor involved in the installation of an APU on the truck depends on the configuration of the truck engine and chassis and the plumbing of its heating/cooling system. Heating and cooling of the cab compartment are accomplished through either dedicated equipment supplied with the APU or through the truck's existing heating and cooling system. APU's are commercially available and meet most of the power needs of truck operators.

Direct-Fired Heaters
Direct-fired heaters for truck heating applications are devices that use the combustion heat of a small IC engine to provide heat directly to the truck's cab/sleeper area through the use of a small heat exchanger. Because it is designed to provide heat directly from a combustion flame, the heating efficiency of these units is higher than that obtained through the truck's engine due to reduced mechanical losses and fuel consumption. Two primary limitations of direct-fired heaters for this application are that they cannot provide cooling and that they draw on the truck's battery power during operation. Direct-fired heater technologies continue to evolve, but they have not gained widespread commercial acceptance.

Thermal Storage/Direct-Fired Heaters
Thermal storage systems provide both heating and cooling for the cab/sleeper area. This technology uses the heat of transformation associated with material phase change to provide heating and cooling to the cab/sleeper area. However, the technology faces several drawbacks: 1) it cannot provide heat to the engine unless a direct-fired heater is also incorporated with the thermal storage system, 2) it cannot provide cooling at night unless the truck's air conditioner was used in the daytime, and 3) it uses the truck's battery power.

Truck Stop Electrification
Another strategy for reducing truck idling is electrification of truck stops or truck rest areas where trucks park. This strategy requires the installation of charging infrastructure at truck stops and rest areas and the retrofit of trucks with components such as engine block heater, fuel heater, and electric heater for cab/sleeper areas. Enabling technologies for an electrification strategy are commercially available. In addition, new and improved technologies are continually developing that may offer significant emission reduction benefit. Currently, these options for cab heating/cooling, electricity, and telephone and internet service, are less intrusive and can be used by any truck with the use of a window connection.

PROJECT CRITERIA
The project criteria for eligible idling reduction strategies for HDV's provide districts and fleet operators with the minimum requirements for participation in the CMP. The criteria are developed specifically for APU's that will be installed on a HD truck to reduce the truck's idling emissions. Other idling reduction strategies can be evaluated on a case-by-case basis. In addition, ARB may develop criteria for other idling reduction strategies when suitable technologies enter the market.

APU's provide a cost-effective means to reduce idling emissions from HD diesel trucks. However, because of the attractive life-cycle cost of this technology, CMP funds cannot pay for the full cost of an APU. Fuel savings to the truck operator who purchases an APU offer a return on the investment that eventually offsets the initial capital cost of the APU. Thus, the role of an incentive program is to promote the introduction of the technology in the near term. The payback period and the amount of fuel savings depend on the total cost of the unit, actual idling hours, fuel prices, and maintenance costs. Therefore, a maximum amount of $1,600 per diesel APU, and $3,100 per alternative fuel or electric motor, is allowed in this project category. These limits have been revised for cost of living increases relative to the those previously allowed under the November 2000 CMP guidelines. This amount is intended to defray the installation cost of the APU. The grant amount depends on the install costs for the project, but in no case can funding exceed $1,600 for a diesel APU and $3,100 for an alternative fuel or fuel cell APU. Eligibility criteria continue to be amount of emission reductions, cost-effectiveness, and ability for the project to be completed within the timeframe of the program.

- Eligible projects must provide at least 15% NOx emission benefit compared to baseline idling NOx emissions.

- NOx reductions obtained through this program must not be required by any existing regulations, memoranda of agreement/understanding, or other legally binding documents.

- The engine used in the APU must meet current emission standards and be certified by the ARB for sale in California. Compliance with all applicable durability and warranty requirements is also expected.

- An hour-meter must be installed with the APU to track operation. This information must be provided to ARB of the participating district upon request during the life of the project.

- The default load factor for the IC engine used in an APU will be the maximum power rating of the engine, unless another load factor is proposed and supported by proper documentation.

- Funded projects must operate for a minimum of 5 years.

- Emission benefits must be based on the vehicle's idling time that occurs in California.

- The actual installation cost of the APU including installation of an hour meter, or up to a maximum of $1,600 per diesel APU installation, and a maximum of $3,100 per alternative fuel, electric motor, or fuel cell APU installation may be funded, whichever is less.

- Projects must meet a cost-effectiveness criterion of $13,600 per ton of NOx reduced.

<u>Sample Application</u>
In order to qualify for incentive funds, districts make applications available and solicit proposals for reduced-emission projects from HDV operators. A sample application form is included in the appendix. The applicant must provide at least the following information listed in Table 10.2.

Table 10.2. Minimum Application Information Auxiliary Power Unit Projects.

1. Air District 2. Project Funding Source: 3. Applicant Demographics Company Name: Business Type: Mailing Address: Location Address: Contact Number: 4. Project Description Project Name: Project Type: Vehicle Function: Vehicle Class: GVWR(lbs): 5. NOx Reduction Incremental Cost Effectiveness Analysis Basis: (Mileage/Fuel/Hours of Operation) 6. VIN or Serial Number: 7. Application: (Repower, Retrofit , Idling, or New) 8. Percent Operated in California: 9. APU Engine Information Horsepower Rating: Engine Make: Engine Model: Engine Year: Fuel Type:	10. NOx Emissions Reductions Baseline NOx Emissions Level (g/hr): APU NOx+HC Emissions Standard (g/kW-hr): Estimated Annual NOx Emissions Reductions: Estimated Lifetime NOx Emissions Reductions: 11. Cost ($) of Certified APU: 12. Installation cost ($) of APU: 13. Annual Diesel Gallons Used: 14. Annual Hours Idled (Must be documented or justified): 15. APU Load Factor (Must be documented or use default value): 16. Project Life (years): 17. Existing Truck Engine Information Truck Horsepower Rating: Truck Engine Make: Truck Engine Model: Truck Engine Year: 18. District Incentive Grant Amount Requested: 19. Project Contact:

EMISSION REDUCTION AND COST-EFFECTIVENESS

The emission reduction benefit represents the difference in the emission level of a baseline idling engine and the APU. The emission level is calculated by multiplying an emission factor by an activity level, and, for the APU, by a load factor. Since emission standards for small off-road CI engines are stated in terms of NOx+HC, the NOx fraction of the standard is assumed to be 95% for diesel and 85% for natural gas. NOx idling emission factors are included in the emission inventory models, which accounts excess in-use NOx emissions from engines under the settlement agreement. The average idling NOx emission factor for heavy HD diesel trucks (33,000 + lbs GVWR) is 81 g/hr according to ARB’s updated emission inventory model.

For auxiliary power unit projects, only the actual installation cost of an eligible new APU is eligible for CMP funding. The maximum installation cost funded by the CMP shall not exceed $1,600 for diesel powered APU's and $3,100 for alternative fuel APU's. In addition, the project must meet the $13,600 per ton of NOx reduced C/E criterion. The total installed cost of the auxiliary power unit is to be used in the cost-effectiveness calculation. That amount is to be amortized over the expected project life (at least five years) and with a discount rate of 3%. The amortization formula (given below) yields a capital recovery factor, which, when multiplied by the initial capital cost, gives the annual cost of a project over its expected lifetime. The reader is referred to Chapter Two for discussions of the current discount rate.

$$\textit{Capital Recovery Factor (CRF)} = [(1 + i)^n\ (i)] / [(1 + i)^n - 1]$$

where, i = discount rate (5%)
n = project life (at least five years)

Example

APU Project (Calculations based on Fuel Consumption and Idling Hours)

A truck operator proposes to purchase an APU, powered by a certified 8 kilowatt (10.7 horsepower) engine, to be installed on a heavy-duty truck to reduce its engine idling hours. This vehicle idles 100 hours per year in California. The load factor for the APU is documented to be 90% of rated power and the APU would substitute for up to 80% of the truck's idling time. The installation cost of the APU on the truck is $1,400.

<u>Emission Reduction Calculation</u>

Baseline Truck NOx Idling Emission Factor:	396 g/hr
APU NOx+HC Emission Standard:	10.5 g/kW-hr
APU NOx Emissions:	0.95*10.5=10 g/kW-hr
Annual Idling Hours in California:	100 hours
Load Factor:	90%
APU Idling Substitution Rate:	80%
Conversion factor:	1 ton = 907,200g

The estimated reductions are:

Since 80% of idling load is attributable to the APU, 20% of actual idling load is still carried out by the truck engine, the hourly NOx emission reduction is:

396 g/hr - ((0.20)(396 g/hr) + (0.80)(10 g/kW-hr)(8kW)(0.90)) = 259.2 g/hr

Annual emission reduction is:

259.2 g/hr* 100 hours/year * ton/907,200 g = **0.03 tons/year NOx emissions**

<u>Cost and Cost-Effectiveness Calculations</u>

The annualized cost is based on the installation cost of the APU, the expected life of the project (5 years), and the interest rate (3%) used to amortize the project cost over the project life. The maximum amount that can be funded by the CMP fund is determined as follows:

APU Capital Cost	= $6,000	
APU Installation Cost	= $1,400	
Moyer Amount Requested	= $1,400	
Capital Recovery	**=** $[(1 + 0.03)^5\ (0.03)]/[(1 + 0.03)^5 - 1]$	= 0.161
Annualized Cost	= (0.1611,400)	= 225/yr

Cost-Effectiveness = (\$225/year)/(0.03 tons/year) **= \$751/ton**

The cost effectiveness for the example is less than \$13,600 per ton of NOx reduced. This project qualifies for the maximum amount of grant funds requested, which, in this case, is the cost of installation cost.

<u>Reporting and Monitoring</u>

The district has the authority to conduct periodic checks or solicit operating records from the applicant that has received CMP funds for HDV idling emission reduction projects. This is to ensure that the APU is operated as stated in the program application. Fleet operators participating in the CMP are required to keep appropriate records during the life of the project. Records must contain, at a minimum, total California hours idled. Records must be retained and updated throughout the project life and made available at the request of the district.

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APPENDIX A

APPLICATION TO ADMINISTER PROGRAM

AND

GRANT AWARD & AUTHORIZATION FORM

Carl Moyer Memorial Air Quality Standards Attainment Program

APPLICATION TO ADMINISTER PROGRAM

Issued by the California Air Resources Board

Revised: March 26, 2003

INTRODUCTION

The Carl Moyer Memorial Air Quality Standards Attainment Program (the Carl Moyer program) provides grants for the incremental cost of cleaner heavy-duty vehicle, off-road equipment, marine, locomotive engines, forklift, and ground support GSE engines. The program is named after the late Dr. Carl Moyer, in recognition of his work in the air quality field, and his efforts in bringing about this incentive program. To date, the Carl Moyer Program has been funded with one-time State appropriations of $25 million for FY 1998/1999, $23 million for FY 1999/2000 ($19 million for heavy-duty engine projects and $4 million for infrastructure and advanced technology development), $50 million for FY 2000/2001 ($45 million for heavy-duty engine projects and $4 million for infrastructure and advanced technology development), and $16 million if FY 2001/2002. Total program funding for the first four years was approximately $114 million. In FY 2002/2003, Proposition 40 (Public Resources Code §5096.650), the California's Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act, will provide $19.5 million for projects at the local district level that "affect air quality in state and local parks and recreation areas" in accordance with CMP guidelines. Additional funding under the Proposition 40 initiative for FY2003/2004 will be provided, pending legislative budget approval.

The Air Resources Board oversees the program and develops program requirements and project criteria. This document is an application for funding for districts that wish to administer a local program.

TENTATIVE TIMETABLE FOR FY 2002/2003

March	ARB receives letter of intent to participate from districts.
May	ARB begins distributing funds.
July	District report on implementation efforts due.
July (following year)	District annual report on project status due. Districts report on funds that are obligated under contract.
June (second year out)	All funds must have been spent on projects. At a minimum, all funds must be committee to purchase orders.
July (second year out)	Deadline for districts to submit final report.

GRANT PROVISIONS

A. Definitions

1. Qualifying project means a project that meets the Carl Moyer Program Guidelines, and which has been approved for funding by the district.
2. District means the air pollution control or air quality management district approved for program administration.

B. Matching Fund Requirements

1. If a district is required to match the funding provided by the Carl Moyer Program, matching funds shall be provided at the level of $1 of district matching for every $2 of Carl Moyer Program funding.
2. Match funding provided by a port authority to the district for the incremental cost of qualifying projects at a port may be counted toward the district's matching fund requirement.
3. Except as provided in B(2), only funding under the district's budget authority may count toward the district matching fund requirement.
4. Up to 15% of district matching funds may be in the form of administrative expenses and other in-kind contributions.
5. Funds provided by the district or port authority for infrastructure for a qualifying project shall count as district matching funds.
6. Funds provided by the district or port authority for project focused on PM emission reductions only shall count as district matching funds only for districts with a matching fund requirement.

C. <u>Cost-Effectiveness</u>

1. For each qualifying project, Carl Moyer Program plus district funding shall not exceed $13,600 per ton of NOx emissions reduced, calculated according to the Carl Moyer Program Guidelines on a project-by-project basis. The exception to this is the forklift category, with 3,000-6,000 pounds lift capacity, which has a maximum of $3,100/ton for retrofit projects.
2. Funding that is not under the district's budget authority, including but not limited to private company funding, and motor vehicle registration fee funding provided by cities and counties in the South Coast Air Basin or the Bay Area, does not have to be included in the cost-effectiveness calculation.
3. Infrastructure funding need not be included in the cost-effectiveness calculation.
4. Port authority funding for incremental cost, if counted toward the matching fund requirement, must be included in the cost-effectiveness calculation.

D. Project Criteria

Districts shall fund only those projects that comply, at a minimum, with the Carl Moyer Program Guidelines, or those projects approved on a case-by-case basis by ARB's Executive Officer.

E. <u>Monitoring/Reporting</u>

1. Districts shall monitor the projects they fund to ensure that the expected emission reductions occur.
2. By July 30th of each year, districts shall submit a report on their implementation efforts using ARB-approved forms and reporting formats. This shall include:

- an overview of application and allocation process
- draft project applications, mailout date(s), targeted types of recipients, the number of recipients of each type on the program mailing list (e.g., 23 trucking firms, 14 warehouse distribution centers, 27 farms)

- names of staff responsible for program implementation
- report on outreach activities (completed and planned)

3. Districts shall report to the ARB by June 30th following the corresponding fiscal year distribution and again by July 31, of the following year on the Carl Moyer Program. The report shall include a description of projects funded, baseline and incremental project costs, infrastructure for qualified vehicle and equipment projects, total state funding, and total district match funding obligated.

F. Project Selection

Districts shall select which of the qualifying projects to fund based on local priorities. Districts may elect to fund qualifying projects on a first come, first served basis. Districts may elect to fund a mix of vehicle, equipment, marine, and locomotive projects. When selecting among competing projects, districts are encouraged to give priority to projects that yield reductions in particulate matter (PM) emissions, as well as the required reductions in NOx emissions. Districts are also encouraged to give priority to the most cost-effective projects, to consider environmental justice, and direct impact to local parks and recreation areas.

FUNDING ALLOCATION

The table that follows shows a tentative funding allocation through fiscal year 2002/2003. Funds allocated to districts that choose not to participate in the program shall be allocated among the participating districts following the same criteria. ARB will determine the final funding allocation.

DISBURSEMENT OF FUNDS

ARB will determine the grant award allocations and begin issuing checks to districts for the initial disbursements by May of 2003. The initial disbursement will be 10% of the district's allocation for districts eligible for additional disbursements or $100,000 for districts eligible for the minimum allocation.

The remaining funds will be disbursed on an as needed basis. When a district has commitments in place for the initial disbursement plus the required matching funds, the district may request a check from ARB for an additional 10% disbursement. ARB will disburse more than 10% of the allocation at a time if the district demonstrates the need based on additional project funding obligations either through signed contracts or local district board approval of projects. Estimated turnaround time for issuance of checks is four to six weeks from the date ARB receives the request.

ARB encourages districts to implement the program quickly, and to have all the funds obligated via contract within one year. Districts must submit a report on project status by June 30th following the distribution of the said fiscal year funds. The report should list projects, state funds spent to date, additional funds obligated via contract, any contracts being negotiated, and remaining state funds that have not yet been obligated.

Carl Moyer Program Funding Allocation Fiscal Year 2002/2003			
Local Air District	Minimum Allocation	Additional Funds (Population and Non-Attainment)	Total Funding
Amador County APCD	$100,000		$100,000
Antelope Valley APCD	$100,000	$158,309	$258,309
Bay Area AQMD	$100,000	$1,678,009	$1,778,009
Butte County AQMD	$100,000		$100,000
Calaveras County APCD	$100,000		$100,000
Colusa County APCD	$100,000		$100,000
Feather River AQMD	$100,000		$100,000
Glenn County APCD	$100,000		$100,000
Great Basin Unified APCD	$100,000		$100,000
Imperial County APCD	$100,000		$100,000
Kern Eastern Desert	$100,000	$137,153	$237,153
Lake County AQMD	$100,000		$100,000
Lassen County AQMD	$100,000		$100,000
Mariposa County APCD	$100,000		$100,000
Mendocino	$100,000		$100,000
Modoc County APCD	$100,000		$100,000
Mojave Desert AQMD	$100,000	$575,375	$675,375
Monterey Bay Unified APCD	$100,000	$181,158	$281,158
North Coast Unified AQMD	$100,000		$100,000
Northern Sierra AQMD	$100,000		$100,000
Northern Sonoma County APCD	$100,000		$100,000
Sacramento Metropolitan AQMD	$400,000	$1,474,808	$1,874,808
San Diego County APCD	$100,000	$717,352	$817,352
San Joaquin Valley Unified APCD	$100,000	$2,879,017	$2,979,017
San Luis Obispo County APCD	$100,000		$100,000
Santa Barbara County APCD	$100,000	$101,809	$201,809
Shasta County AQMD	$100,000		$100,000
Siskiyou County APCD	$100,000		$100,000
South Coast AQMD	$100,000	$7,510,628	$7,610,628
Tehama County APCD	$100,000		$100,000
Tuolumne County APCD	$100,000		$100,000
Ventura County APCD	$100,000	$586,384	$686,384
TOTAL	**$3,500,000**	**$16,000,000**	**$19,500,000**

Any funds not obligated under contract after one year may be reallocated to other reserves the right to require periodic progress reports, and to reallocate unobligated funding at any time thereafter.

FISCAL YEAR:_______ APPLICATION
FOR CARL MOYER PROGRAM FUNDS

1. APPLICANT DISTRICT

District Name ______________________________
Street Address ______________________________
City/Zip __________________________________
Contact Person ____________Phone____________

2. MATCH FUNDING ALREADY COMMITTED TO PROJECTS

District funds already obligated for qualifying projects __________________________________
(include funds obligated between ________________and ________________ for projects that would have qualified for Carl Moyer Program funding had it been available.)

3. DISTRICT MATCHING FUNDS

Committed as match funding for this program from ________________ through __________________:

Motor Vehicle Registration Fee Funds ____________________________
Other District Funds (please specify type) ____________________________
____

4. CARL MOYER PROGRAM FUNDING REQUESTED ____________________________

5. DESCRIPTION OF PROJECTS FUNDED

Attach a description of projects included in 2 above. Include detailed project descriptions so ARB can determine whether the project funding qualifies as Carl Moyer program match funding.

To the best of my knowledge and belief, data in this application are true and correct. The document has been duly approved and authorized by the governing board of the applicant and the applicant will maintain program compliance with the criteria listed in the Carl Moyer Program Guidelines.

6. District

____
Signature Typed Name, Title Date

Carl Moyer Memorial Air Quality Standards Attainment Program
GRANT AWARD & AUTHORIZATION FORM
Fiscal Year:__________

Your FY ________ application for Carl Moyer Program funds has been approved as follows:

District:
Grant Award:
Required Match Amount:
Grant Number:

You are authorized to administer a local program according to the requirements described inthe following documents, which are attached and incorporated as part of this grant:

Completed Application to Administer Program (Attachment A)
Carl Moyer Program Guidelines (Attachment B)
Contacts (Attachment C)
Grant Disbursement Request (Attachment D)

The undersigned parties agree to the terms and conditions as set forth in this grant. The undersigned parties certify under the penalty of perjury that they are duly authorized to bind the parties to this grant.

California Air Resources Board:	**District:**
______________________________	______________________________
Signature of Authorized Official	**Signature of Authorized Official**
Name: Marie LaVergne	Name:
Title: Administrative Services Division Chief	Title:
Date: ______________________	Date: ______________________

ATTACHMENT C
CONTACTS

The ARB contact for general program issues relating to this grant is Cindy Sullivan. Correspondence regarding program issues, including required program reports, should be directed to:

Alberto Ayala, Manager Phone: (916) 327-2952
Alternative Strategies
Mobile Source Control Division, North
Air Resources Board
P.O. Box 2815
Sacramento, California 95812

The ARB contact for financial matters relating to this grant is Mr. Blaine Oborn. Correspondence regarding financial matters, including funding requests after the initial disbursement, should be directed to:

Rozanne McPhee Phone: (916) 324-9907
Administrative Services Division
Air Resources Board
P.O. Box 2815
Sacramento, California 95812

For technical questions relating to engine certification, please contact Duc Nguyen at (626) 575-6844. For technical questions regarding stationary agricultural pumps, please contact Mike Tollstrup at (916) 323-8473. For technical questions regarding other source categories, please contact Bob Nguyen at (916) 327-2939 or Chuck Bennett at (916) 322-2321.

ATTACHMENT D
GRANT DISBURSEMENT REQUEST

Funding Category	Carl Moyer Program Funds	District Funds
Total Carl Moyer Program allocation		
Total match funding required		
Carl Moyer Program funds received		
Project funding obligated via contract to date		
Infrastructure funding obligated via contracts		
Funds will be disbursed in increments of 10% of your allocation, unless additional funds are needed to meet contractual obligations. If so, state amount requested.		

I certify to the best of my knowledge and belief that the information contained in this grant disbursement request, including the amount of project funding obligated contract, is correct and complete and is in accordance with the grant. In addition, I hereby authorize the Air Resources Board to make any inquiries to confirm this information.

District:

____

Signature of Authorized Official

Name:
Title:

____________________ Date:

APPENDIX B

ON-ROAD HEAVY-DUTY VEHICLES
PROJECT APPLICATION

Carl Moyer Memorial Air Standards Attainment Program
ON-ROAD HEAVY-DUTY VEHICLE PROJECT
APPLICATION

This application is for incentive funds for the purchase of new, reduced-emission on-road heavy-duty vehicle, vehicle repowers, and engine retrofits.

Please provide the following information regarding your proposed purchase and application. Additional information may be requested during the review process if needed. Applicant acknowledges that award of cash incentive is conditional upon approval of the District and must meet the minimum eligibility criteria.

Within ten working days of submission, you will either be notified that your application is complete, or provided with a list of deficiencies. Completed applications fulfilling the criteria will be approved within 60 working days of receipt. If you have any questions regarding the application process, please contact:

District Incentive Program Contact
Contact Phone Number

✔ CHECK LIST FOR APPLICATION ITEMS ✔

Be sure the following items are included with your application submittal. Check each applicable box below to indicate inclusion of material.

❏ Completed Applicant Information Form

❏ Letter of Agreement from Fuel Provider (if applicable)

❏ Co-funding Information (if applicable)

❏ Other____________________________________

✔ CHECK LIST FOR ELIGIBILITY CRITERIA ✔

Please check each applicable box below to indicate eligibility of proposed heavy-duty vehicle/engine technology project.

The reduced-emission engine/technology:

- ❑ is certified for sale in California, or
- ❑ is under experimental permit for operation in California,

and

A. For new vehicle purchase projects:
   - ❑ New engine certified to ARB NOx+NMHC emission credit standard that is at least 30 percent lower than the baseline NOx+NMHC emission level of the engine being replaced;

B. For vehicle repower projects:
   - ❑ Pre-1987 model year heavy-duty trucks—the replacement engine is a mechanical engine certified to a NOx emission level of 6.0g/bhp-hr or better:
   - ❑ *Pre-1987 model year replacement engine is a certified engine manufactured on or after October 1, 2002*
   - ❑ *Post-1987 model year electronic engine replacement engine is a certified heavy-duty electronically controlled engine manufactured on or after October 1, 2002.*

C. For retrofit kit or add-on equipment projects:
   - ❑ shows at least a 15 percent reduction of NOx, or NOx+NMHC, emissions, and no significant increase in particulate emissions, compared to the applicable standards for that engine year and type of application through:
     - ❑ ARB certification testing, or
     - ❑ U.S. EPA certification testing, or
     - ❑ Emission testing at a laboratory approved by U.S. EPA or ARB.
   - ❑ The retrofit technology is warranted by retrofit manufacturer and/or authorized dealer.

D. For Auxiliary Power Unit (APU) projects.

❑ Shows at least 15 percent reduction in NOx emissions over the heavy-duty diesel truck baseline idling emission rate.

❑ The engine used in the APU is certified by the ARB to the current emission standards and the APU is equipped with an hour meter.

E. The purchase is not required by any local, state, or federal rule or regulation, or used to comply with any such rule or regulation.

F. The purchase is not required by any local, state, or federal MOU or MOA.

G. Seventy-five percent or more of the vehicle's miles driven, fuel consumption, or hours of operation or idling, shall be within California, for at least five (5) years from the date the vehicle is placed into service with the new technology.

ON-ROAD HEAVY-DUTY VEHICLE APPLICATION
Please Print or Type All Information on This and Any Attached Applications.

A. APPLICANT INFORMATION:		
Organization/ Company Name:		
Project Name:		
Contact name:		
Person with contract signing authority:		
Street/mailing address:		
City:	State:	Zip code:
Phone: ( )	Fax: ( )	
E-mail:		
Geographic area served by organization:		
Geographic area to be served by vehicle (if different than above):		
Number of heavy-duty vehicles in fleet:		

Please check one:

❏ Vehicle is in line haul service
❏ Vehicle is in urban bus/school bus service
❏ Vehicle is in other heavy-duty services (Describe:____________________)

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

NEW HEAVY-DUTY VEHICLE PURCHASE APPLICATION SECTION

B. GENERAL INFORMATION ABOUT EACH NEW HEAVY-DUTY VEHICLE
1. Number of vehicle purchased:
2. Fuel type:
3. Primary function of vehicle (e.g., line haul, local deliver, or passenger):
4. Estimated total annual hours of operation: Or,
5. Estimated total annual mileage: Or,
6. Estimated annual fuel consumption (in gallons) for each vehicle:
7. Percent within district boundaries:
8. Is there any seasonality to the use of the vehicle? YES/NO If Yes, please explain:

NEW REDUCED-EMISSION VEHICLE
8. Vehicle Class:
9. Vehicle make:
11. Vehicle model:
12. Model year:
13. Gross Vehicle Weight Rating (GVWR):
14. Engine make:
15. Engine model number:
16. Horsepower:
17. New Engine NOx, or NOx+NMHC, Emission Factor:
18. New Engine PM Emission Factor:
19. Estimated vehicle life:

20. Estimated replacement schedule:
21. Cost of new heavy-duty vehicle that meets current emission NOx+NMHC standard (2.4 or 2.5 g/bhp-hr):
22. Cost of new heavy-duty vehicle that meets ARB optional NOx+NMHC standards (<= 1.8 g/bhp-hr):
23. Differential cost of project:

Please check one:

- ❑ New reduced-emission vehicle meets ARB optional NOx+NMHC standard of 1.8 g/bhp-hr or less.
- ❑ New reduced-emission vehicle does not meet ARB optional NOx+NMHC standard of 1.8 g/bhp-hr or less.

C. GENERAL INFORMATION ABOUT THE MANUFACTURER/DEALER

Complete the appropriate information, then go to Section F.

NEW HEAVY-DUTY VEHICLE WITH A NEW REDUCED-EMISSION ENGINE	
Manufacturer/Dealer:	
Street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	

HEAVY-DUTY VEHICLE REPOWER/RETROFIT APPLICATION SECTION

Please check one:

- ❑ Repowering a heavy-duty vehicle with a new reduced-emission engine
- ❑ Retrofitting a heavy-duty engine with a new reduced-emission technology
- ❑ Installing an auxiliary power unit to reduce idling emissions

D. GENERAL INFORMATION ABOUT EACH ENGINE FOR REPOWER OR RETROFIT
1. Number of engines, or APUs to be purchased/retrofitted:
2. Fuel type:
3. Primary function of each vehicle (e.g., line haul, local delivery, or passenger):
4. Estimated total annual hours of operation or annual hours idling time in California: Or,
5. Estimated total annual mileage: Or,
6. Estimated annual fuel consumption (in gallons) for each vehicle/APU:
7. Percent within district boundaries:
8. Is there any seasonality to the use of the vehicle/APU? YES/NO If Yes, please explain:

CURRENT VEHICLE/ENGINE	**NEW REDUCED-EMISSION ENGINE/RETROFIT/APU**
9. Vehicle make/model:	Vehicle make/model: *Same as current*
10. Model year:	Model year: *Same as current*
11. Engine make:	Engine make:
12. Engine model number:	Engine model number:
13. Serial number of engine:	Serial number of engine:
14. Horsepower:	Horsepower:
15. Average vehicle life:	Estimated remaining vehicle life:
16. Typical rebuild/replacement schedule:	Estimated rebuild/replacement schedule:
17. NOx, or NOx+NMHC Emissions Factor:	NOx, or NOx+NMHC Emissions Factor: (For APU, certified NOx+HC Emission Factor (g/bhp-hr)):

18. PM Emissions Factor:	PM Emissions Factor:
19. Cost of replacing or rebuilding existing engine:	Capital cost of APU:
20. Cost of replacing or rebuilding engine with low emission technology:	Installation Cost of APU:
21. Fuel cost due to truck engine idling (for APU projects)	APU Load Factor:
22. *No current cost*	
23. *No current cost*	

Please check one:

❑ Repower of pre-1987 heavy-duty vehicles with engines certified to ARB emission standards and achieve at least 15 percent NOx emission reductions from existing NOx emission standards.

❑ Retrofit kit is certified to reduce NOx emissions by at least 15 percent and complies with ARB emission credit standards.

❑ Install APU in HDV that achieves at least 15 percent NOx idling emission reduction.

❑ Proposed repowering or retrofitting projects does not achieve the required emission reductions.

Complete the appropriate information, then go to Section F.

E. GENERAL INFORMATION ABOUT THE INSTALLER

REDUCED-EMISSION HEAVY-DUTY ENGINE FOR REPOWER (replacement)	
Engine installer:	
Street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	

OR

HEAVY-DUTY VEHICLE REPOWER/RETROFIT/APU APPLICATION SECTION (*continued*)

RETROFIT/APU TECHNOLOGY	
Retrofit/APU manufacturer:	
Retrofit/APU Installer:	
Installer street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	Retrofit kit number:
Description of Retrofit/APU technology:	

ALL APPLICANTS MUST COMPLETE THE FOLLOWING SECTION.

F. OTHER INFORMATION

MAINTENANCE
Describe your maintenance facility and practices, including any training regarding the low-emission technology. If the training has not been completed, provide a time line for completion.

REFUELING (for alternative fuels)
Describe how, and where the vehicle will be refueled (e.g., on-site, existing facility, mobile/skid mounted equipment, etc.) Attach written verification of access to refueling facility.

APPENDIX C

OFF-ROAD EQUIPMENT
PROJECT APPLICATION

Carl Moyer Memorial Air Standards Attainment Program
OFF-ROAD EQUIPMENT PROJECT
APPLICATION

This application is for incentive funds for the purchase of new, reduced-emission off-road equipment, equipment repowers, and/or engine retrofits.

Please provide the following information regarding your proposed purchase and application. Additional information may be requested during the review process if needed. Applicant acknowledges that award of cash incentive is conditional upon approval of the District and must meet the minimum eligibility criteria.

Within ten working days of submission, you will either be notified that your application is complete, or provided with a list of deficiencies. Completed applications fulfilling the criteria will be approved within 60 working days of receipt. If you have any questions regarding the application process, please contact:

District Incentive Program Contact
Contact Phone Number

✔ CHECK LIST FOR APPLICATION ITEMS ✔

Be sure the following items are included with your application submittal. Check each applicable box below to indicate inclusion of material.

❏ Completed Applicant Information Form

❏ Letter of Agreement from Fuel Provider (if applicable)

❏ Co-funding Information (if applicable)

❏ Other________________________________

✔ CHECK LIST FOR ELIGIBILITY CRITERIA ✔

Please check each applicable box to indicate eligibility of proposed off-road equipment technology.

- ❑ The off-road equipment is 50 horsepower or greater.
- ❑ The reduced-emission engine/technology:
  - ❑ is certified for sale in California, or
  - ❑ is under experimental permit for operation in California,

and

A. For new equipment purchase projects:
- ❑ is certified to ARB NOx, or NOx+NMHC, emission credit standard that is at least 30 percent lower than the existing NOx, or NOx+NMHC, emission standard.

B. For equipment repower projects:
- ❑ is certified to the current emission standards, or, if that is not feasible, to a NOx emission level of 6.9 g/bhp-hr, or lower, if replacing an uncontrolled engine, or
- ❑ is certified to ARB NOx, or NOx+NMHC, emission credit standard that is at least 15 percent lower than the NOx, or NOx+NMHC, emission level of the engine being replaced if replacing an emission-certified-engine.

C. For retrofit kit or add-on equipment projects:
- ❑ shows at least a 15 percent reduction of NOx, or NOx+NMHC, emissions, and no increase in particulate matter emissions, compared to the applicable standards or emission levels for that engine year and type of application through:
  - ❑ ARB certification testing, or
  - ❑ U.S. EPA certification testing, or
  - ❑ Emission testing at a laboratory approved by the U.S. EPA or the ARB.
- ❑ The retrofit technology is warranted by retrofit manufacturer and/or authorized dealer.

D. The purchase is not required by any local, state, or federal rule or regulation, or used to comply with any such rule or regulation.

E. The purchase is not required by any local, state, or federal MOU or MOA.

F. The amount of emission reduction is not required by any local, state, or federal MOU or MOA.

G. Seventy-five percent or more of the equipment fuel consumption or hours of operation will be within California, for at least five (5) years from the date the equipment is placed into service with the new technology.

OFF-ROAD EQUIPMENT APPLICATION

A. APPLICANT INFORMATION:		
Organization/Company Name:		
Business Type:		
Project Name:		
Contact Name:		
Person with contract signing authority:		
Street/mailing address:		
City:	State:	Zip code:
Phone: ( )	Fax: ( )	
E-mail:		
Geographic area served by organization:		
Geographic area to be served by equipment (if different than above):		
Number of heavy-duty equipment in fleet:		

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

NEW OFF-ROAD EQUIPMENT PURCHASE APPLICATION SECTION

B. GENERAL INFORMATION ABOUT EACH NEW OFF-ROAD EQUIPMENT
1. Number of equipment purchased:
2. Fuel type:
3. Primary function of equipment (e.g., construction: earth mover; agriculture: tractor):
4. Estimated total annual hours of operation: Or,
5. Estimated annual fuel consumption (in gallons) for each equipment:
6. Percent within district boundaries:
7. Is there any seasonality to the use of the equipment? YES/NO If Yes please explain:

NEW REDUCED-EMISSION EQUIPMENT
8. Equipment make:
9. Equipment model:
10. Model year:
11. Engine make:
12. Engine model number:
13. Fuel Type:
14. Horsepower:
15. Certified NOx, or NOx+NMHC, Emission Standard:
16. Certified PM Emission Standard:
17. Estimated equipment life:
18. Estimated replacement schedule:
19. Cost of new off-road equipment that meets current emission NOx, or NOx+NMHC, standard:
20. Cost of new off-road equipment that meets ARB optional NOx, or NOx+NMHC, standard for off-road engines (<= 5.0 g/bhp-hr):
21. Differential cost of project:

Please check one:

- ❑ New reduced-emission engine is certified to ARB optional NOx, or NOx+NMHC, standard that is at least 30 percent lower than the existing NOx, or NOx+NMHC, standard.
- ❑ New reduced-emission engine is not certified to ARB optional NOx, or NOx+NMHC, standard that is at least 30 percent lower than the existing NOx, or NOx+NMHC, standard.

C. GENERAL INFORMATION ABOUT THE MANUFACTURER/DEALER

Complete the appropriate information, then go to Section F.

NEW OFF-ROAD EQUIPMENT WITH A NEW REDUCED-EMISSION ENGINE	
Manufacture/Dealer:	
Street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	

OFF-ROAD EQUIPMENT REPOWER/RETROFIT APPLICATION SECTION

Please check one:

❑ Repowering an off-road equipment with a new reduced-emission engine
❑ Retrofitting an off-road equipment with a new reduced-emission technology

D. GENERAL INFORMATION ABOUT EACH ENGINE FOR REPOWER OR RETROFIT
1. Number of engines to be purchased/retrofitted:
2. Fuel type:
3. Primary function of each equipment (e.g., construction: earth mover; agriculture: tractor):
4. Estimated total annual hours of operation:
5. Or, estimated annual fuel consumption (in gallons) for each vehicle:
6. Percent within district boundaries:
7. Is there any seasonality to the use of the vehicle? <u>YES/NO</u> If Yes, please explain:

CURRENT EQUIPMENT/ENGINE	**NEW REDUCED-EMISSION ENGINE/RETROFIT**
8. Equipment make/model:	Equipment make/model: *Same as current*
9. Model year:	Model year: *Same as current*
10. Engine make:	Engine make:
11. Engine model number:	Engine model number:
12. Serial number of engine:	Serial number of engine:
13. Horsepower:	Horsepower:
14. Fuel Type:	Fuel Type:
15. Average equipment life:	Estimated remaining equipment life:
16. Typical rebuild/replacement schedule:	Estimated rebuild/replacement schedule:
17. Cost of replacing or rebuilding engine:	Certified PM emission Standard:
18. Cost of replacing or rebuilding engine with low- emission technology:	Cost of replacing or rebuilding engine with low emission technology: $
19. NOx, or NOx+NMHC, Emission Standard:	Certified NOx, or NOx+NMHC, Emission Standard
20. PM emission Standard:	

OFF-ROAD EQUIPMENT REPOWER/RETROFIT APPLICATION SECTION (*continued*)

Please check one:

- ❑ Repower of uncontrolled engine—the new replacement engine is certified to the current emission standards, or, if not feasible, to a NOx level of 6.9 g/bhp-hr, or less.
- ❑ Repower of emission-certified engine—the new replacement engine is certified to ARB NOx, or NOx+NMHC, standard that is at least 15 percent lower than the NOx, or NOx+NMHC, emission level of the engine being replaced.
- ❑ Retrofitted engine achieves at least 15 percent emission reductions from baseline engine NOx, or NOx+NMHC, emission levels.
- ❑ Repower or retrofit engine does not achieve the required NOx emission reductions.

Complete the appropriate information, then go to Section F.

E. GENERAL INFORMATION ABOUT THE INSTALLER

REDUCED-EMISSION OFF-ROAD EQUIPMENT FOR REPOWER (replacement)	
Engine installer:	
Street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	

OR

RETROFIT TECHNOLOGY	
Retrofit manufacturer:	
Retrofit Installer:	
Installer street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	Retrofit kit number:
Description of retrofit technology:	

All applicants must complete this section.

F. OTHER INFORMATION

MAINTENANCE
Describe your maintenance facility and practices, including any training regarding the low-emission technology. If the training has not been completed, provide a time line for completion.

REFUELING (for alternative fuels)
Describe how, and where the vehicle will be refueled (e.g. on-site, existing facility, mobile/skid mounted equipment, etc.) Attach written verification of access to refueling facility.

APPENDIX D

LOCOMOTIVES
PROJECT APPLICATION

Carl Moyer Memorial Air Quality Standards Attainment Program
LOCOMOTIVE PROJECT
APPLICATION

This application is for incentive funds for the purchase of locomotive reduced-emission engines, repowers, retrofits, and other verified NOx emission reducing technology.

Please provide the following information regarding your proposed purchase and application. Additional information may be requested during the review process if needed. Applicant acknowledges that award of cash incentive is conditional upon approval of the District and must meet the minimum eligibility criteria.

Within ten working days of submission, you will either be notified that your application is complete, or provided with a list of deficiencies. Completed applications fulfilling the criteria will be approved within 60 working days of receipt. If you have any questions regarding the application process, please contact:

District Incentive Program Contact
Contact Phone Number

✔ CHECK LIST FOR APPLICATION ITEMS ✔

Be sure the following items are included with your application submittal. Check each applicable box below to indicate inclusion of material.

- ❑ Completed Applicant Information Form
- ❑ Letter of Agreement from Fuel Provider (if applicable)
- ❑ Co-funding Information (if applicable)
- ❑ Other_________________________________

✔ CHECK LIST FOR ELIGIBILITY CRITERIA ✔

Please check each applicable box to indicate eligibility of proposed locomotive engine technology.

❑ The existing locomotive is used in line haul services.
❑ The existing locomotive is used in short line services.
❑ The existing locomotive is used in switch yard services.
❑ The existing locomotive is used in passenger services.
❑ The proposed engine technology is eligible for program funding.

Check applicable categories below:

The reduced-emission engine/technology:

❑ has been tested, or
❑ is under experimental permit for operation in California,

and

For retrofit kits or add-on equipment projects:

❑ shows required reduction of NOx emissions and no significant increase in particulate emissions compared to the applicable United States Environmental Protection Agency's (USEPA) standard for that engine year and type of application through:

❑ California Air Resources Board (ARB) testing,
❑ U.S. EPA testing, or
❑ Emission testing at a laboratory approved by the U.S. EPA or the ARB.

❑ The retrofit technology is warranted by retrofit manufacturer.

❑ The purchase is not required by any local, state, or federal rule or regulation, or used to comply with any such rule or regulation.

❑ The purchase is not required by any local, state, or federal binding agreement.

❑ The amount of emission reduction is not required by any local, state, or federal binding agreement.

❑ Seventy-five percent or more of the locomotive annual miles and ton-miles traveled or hours of operation will be within the boundaries of California for at least five (5) years from the date the locomotive is placed into service with the new technology.

LOCOMOTIVE APPLICATION
Please Print or Type All Information on This and Any Attached Applications.

A. APPLICANT INFORMATION:			
Organization/Company Name:			
Business Type:			
Contact name:			
Person with contract signing authority:			
Street/mailing address:			
City:	State:	Zip Code:	Air District:
Phone: ( )		Fax: ( )	
E-mail:			
Geographic area served by organization:			
Geographic area to be served by locomotive (if different than above):			
Number of locomotives in fleet (if available):			

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

LOCOMOTIVE REPOWER/RETROFIT APPLICATION SECTION

Please check one:

❑ Repowering a locomotive with a new reduced-emission engine (replacement)
❑ Retrofitting a locomotive engine with a new reduced-emission technology

B. GENERAL INFORMATION ABOUT EACH ENGINE FOR REPOWER OR RETROFIT	
1. Number of engines to be purchased/retrofitted:	
2. Fuel type:	
3. Primary function of each locomotive (e.g. short line, switch yard, line haul, or passenger):	
4a. Estimated total annual hours of operation:	4b. Percent within California:
5a. Estimated total annual mileage:	5b. Percent within California:
6. Estimated total annual ton-miles:	
7. Estimated annual fuel consumption/rate (in gallons or gallons/hour) for each locomotive:	8. Incentive Amount Requested:
9. Estimated Project life:	
10. Is there any seasonality to the use of the locomotive? <u>YES/NO</u> If Yes, please explain:	

CURRENT LOCOMOTIVE/ENGINE	**NEW REDUCED EMISSION ENGINE/RETROFIT**
11. Model year:	Model year: *Same as current*
12. Engine make:	Engine make:
13. Engine model year:	Engine model year:
14. Engine model number:	Engine model number:
15. Serial number of engine:	Serial number of engine: (to be provided when available)
16. Horsepower:	Horsepower:
17. Injector Type	Injector Type

LOCOMOTIVE REPOWER/RETROFIT APPLICATION SECTION (*continued*)

17 a. Estimated locomotive engine life (yrs): b. Estimated engine life remaining (yrs): c. Estimated dollar value:	Estimated locomotive engine life (yrs):
18. Typical remanufacture/replacement schedule:	Typical remanufacture/replacement schedule:
19. Cost of remanufacture w/out control upgrade: $	Cost of remanufacture with control upgrade: $
20. Baseline NOx Emission Level (g/bhp-hr)	Controlled NOx emission Level (g/bhp-hr):
21. Baseline PM emission Level (g/bhp-hr):	Controlled PM emission Level (g/bhp-hr):

Please check one:

- ❑ Repower or retrofit of pre 1973 engine achieves required 15 percent emission reduction from current uncontrolled emissions.
- ❑ Repower or retrofit of a 1973 and later model year engine tests to either federal Tier 1 or Tier 2 standards.
- ❑ Repower or retrofit of a pre 1973 model year engine does not achieve required 15 percent emission reduction from uncontrolled baseline emissions (see line 19 above).
- ❑ Repower or retrofit of a 1973 and later model year engine does not test to either federal Tier 1 or Tier 2 standards (see line 19 above).

Complete the appropriate information, then go to Section F.

E. GENERAL INFORMATION ABOUT THE INSTALLER

LOCOMOTIVE ENGINE FOR REPOWER (replacement)	
Engine installer:	
Street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	

OR

LOCOMOTIVE REPOWER/RETROFIT APPLICATION SECTION (*continued*)

RETROFIT OR OTHER NOx EMISSION REDUCTION TECHNOLOGY	
Retrofit manufacturer:	
Retrofit Installer:	
Installer street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	Retrofit kit number:
Description of retrofit technology:	

All applicants must complete this section.

F. OTHER INFORMATION

MAINTENANCE
Describe your maintenance facility and practices, including any training regarding the low-emission technology. If the training has not been completed, provide a time line for completion.

REFUELING (for alternative fuels)
Describe how, and where the locomotive will be refueled (e.g. on-site, existing facility, mobile/skid mounted equipment, etc.) Attach written verification of access to refueling facility.

APPENDIX E

MARINE VESSELS
PROJECT APPLICATION

Carl Moyer Memorial Air Quality Standards Attainment Program
MARINE VESSEL PROJECT
APPLICATION

This application is for incentive funds for the purchase of reduced-emission engines used in marine vessels, repowers, and/or retrofits.

Please provide the following information regarding your proposed purchase and application. Additional information may be requested during the review process if needed. Applicant acknowledges that award of cash incentive is conditional upon approval of the District/Port and must meet the minimum eligibility criteria.

Within ten working days of submission, you will either be notified that your application is complete, or provided with a list of deficiencies. Completed applications fulfilling the criteria will be approved within 60 working days of receipt. If you have any questions regarding the application process, please contact:

District Incentive Program Contact
Contact Phone Number

✔ CHECK LIST FOR APPLICATION ITEMS ✔

Be sure the following items are included with your application submittal. Check each applicable box below to indicate inclusion of material.

❏ Completed Applicant Information Form

❏ Letter of Agreement from Fuel Provider (if applicable)

❏ Co-funding Information (if applicable)

❏ Other_________________________________

✔ CHECK LIST FOR ELIGIBILITY CRITERIA ✔

Please check each applicable box to indicate eligibility of proposed marine vessel engine technology.

- ❑ The existing marine vessel is used as an auto carrier.
- ❑ The existing marine vessel is used as a bulk carrier.
- ❑ The existing marine vessel is used as a container ship.
- ❑ The existing marine vessel is used as general cargo.
- ❑ The existing marine vessel is used as a passenger ship.
- ❑ The existing marine vessel is used as a reefer.
- ❑ The existing marine vessel is used as a RORO.
- ❑ The existing marine vessel is used as a tanker.
- ❑ The existing marine vessel is used as tug/tow/push boat.
- ❑ The existing marine vessel is used as a work/supply/utility boat.
- ❑ The existing marine vessel is used as a fishing vessel.
- ❑ The existing marine vessel is used as a U. S. Navy ship.
- ❑ The proposed engine technology is eligible for program funding.

Check applicable categories below:

The reduced-emission engine/technology:

- ❑ has been tested, or
- ❑ is under experimental permit for operation in California,

and

For retrofit kits or add-on equipment projects:

- ❑ shows the required reduction of NOx emissions and no significant increase in particulate emissions compared to the applicable United States Environmental Protection Agency's (USEPA) standard for that engine year and type of application through:

  - ❑ California Air Resources Board (ARB) testing,
  - ❑ U.S. EPA testing, or
  - ❑ Emission testing at a laboratory approved by the U.S. EPA or the ARB.

- ❑ The retrofit technology is warranted by retrofit manufacturer.

- ❑ The purchase is not required by any local, state, federal or international maritime rule, regulation, or binding agreement.

- ❑ The amount of emission reduction is not required by any local, state, federal, or international maritime rule, regulation, or binding agreement.

MARINE VESSEL APPLICANT INFORMATION SECTION
Please Print or Type All Information on This and Any Attached Applications.

A. APPLICANT INFORMATION:			
Organization/Company Name:			
Project Name:			
Business Type:			
Contact name:			
Person with contract signing authority:			
Street/mailing address:			
City:	State:	Zip code:	Air District:
Phone: ( )		Fax: ( )	
E-mail:			
Geographic area served by organization:			
Geographic area to be served by marine vessel (if different than above):			
Number of marine vessels in fleet:			

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

MARINE VESSEL REPOWER/RETROFIT APPLICATION SECTION

Please check one:

- ❑ Repowering a marine vessel with a new reduced-emission engine (replacement)
- ❑ Retrofitting a marine vessel engine with a new reduced-emission technology

B. GENERAL INFORMATION ABOUT EACH ENGINE FOR REPOWER OR RETROFIT	
1. Number of engines to be purchased/retrofitted/repowered:	
2. Dead weight tonnage (DWT):	
3. Type of engines:	
4. Fuel type for each engine (if applicable):	
5. Primary function of each marine vessel (e.g. auto carrier, container ship, general cargo, passenger ship, reefer, RORO, tanker, tug/tow/push boat, work/supply/utility boats, fishing vessel, and/or U.S.. Navy ship):	
6. Propulsion type (motorship, or steamship):	
7. Annual number of port calls in a port:	8. Annual number of port calls in a California:
9. Estimated total annual hours of operation per port call in each service mode: a. Cruise: b. P-Zone Cruise: c. Maneuvering: d. Hotelling:	10. Average ship service speed in each service mode: a. Cruise: b. P-zone cruise: c. Maneuvering: d. Hotelling
11. Average fuel consumption/rate (gallons or gallons/hour) per port call for each service mode: a. Cruise: b. P-Zone Cruise: c. Maneuvering: d. Hotelling:	12. Average fuel consumption (gallons) per port call for auxiliary power (if applicable): a. Boilers (motorship): b. Engines (motorship): c. Main boilers (steamship):
13a. Estimated total annual nautical miles in California coastal water boundary::	13b. Percent within California boundaries:
14. Estimated annual fuel consumption (in gallons) for each marine vessel:	15. Incentive Amount Requested:
16. Estimated Project Life:	
17. Is there any seasonality to the use of the marine vessel? YES/NO If Yes, please explain:	

MARINE VESSEL REPOWER/RETROFIT APPLICATION SECTION (continued)

CURRENT MARINE VESSEL/ENGINE	NEW REDUCED EMISSION ENGINE/RETROFIT
18. Model year:	Model year: *Same as current*
19 Engine make:	Engine make: *Same as current*
20. Engine model number:	Engine model number:
21. Serial number of engine:	Serial number of engine: (to be provided when available)
22. Horsepower:	Horsepower:
23. Average engine life (yrs): a. Estimated locomotive engine life (yrs): b. Estimated engine life remaining (yrs): c. Estimated dollar value:	Average marine vessel engine life (yrs):
24. Typical rebuild/replacement schedule:	Typical rebuild/replacement schedule:
25. Cost of replacing/rebuilding engine w/out control: $	Cost of replacing/rebuilding engine with control: $
26. NOx emission level w/out control (lbs/1000 gals):	NOx emission level with control (lbs/1000 gals):
27. PM emission level:	PM emission level:

<u>Please check one:</u>

❑ Repower or retrofit of engine achieves required emission reduction from baseline uncontrolled emissions.

❑ Repower or retrofit of engine does not achieve required emission reduction from baseline uncontrolled emissions (see line 26 above).

MARINE VESSEL REPOWER/RETROFIT APPLICATION SECTION (continued)

Complete the appropriate information, then go to Section F.

E. GENERAL INFORMATION ABOUT THE INSTALLER

MARINE VESSEL ENGINE FOR REPOWER (replacement)	
Engine installer:	
Street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	

OR

RETROFIT TECHNOLOGY	
Retrofit manufacturer:	
Retrofit Installer:	
Installer street address:	
City:	State:
Phone: ( )	Fax: ( )
Contact name:	Retrofit kit number:
Description of retrofit technology:	

MARINE VESSEL REPOWER/RETROFIT APPLICATION SECTION *(continued)*

All applicants must complete this section.

F. OTHER INFORMATION

MAINTENANCE
Describe your maintenance facility and practices, including any training regarding the low-emission technology. If the training has not been completed, provide a time line for completion.

REFUELING (for alternative fuels)
Describe how, and where the marine vessel will be refueled (e.g. on-site, existing facility, mobile/skid mounted equipment, etc.) Attach written verification of access to refueling facility.

APPENDIX F

STATIONARY AGRICULTURAL IRRIGATION PUMPS
PROJECT APPLICATION

Carl Moyer Memorial Air Standards Attainment Program

STATIONARY AGRICULTURAL ENGINE

- APPLICATION

This application is to be used for incentive funds for stationary agricultural engine repowers, engine replacements with electric motors, and/or engine retrofit projects.

Please provide the following information regarding your proposed purchase and application. Additional information may be requested during the review process if needed. Applicant acknowledges that award of cash incentive is conditional upon approval of the District and must meet the minimum eligibility criteria.

Within ten working days of submission, you will either be notified that your application is complete, or provided with a list of deficiencies. Completed applications fulfilling the criteria will be approved within 60 working days of receipt. If you have any questions regarding the application process, please contact:

District Incentive Program Contact
Contact Phone Number

✔ CHECK LIST FOR APPLICATION ITEMS ✔

Be sure the following items are included with your application submittal. Check each applicable box below to indicate inclusion of material.

❏ Completed General Information

❏ Completed Engine Repower or Retrofit Information

❏ Completed Electric Motor Replacement Information

❏ Co-funding Information (if applicable)

❏ Other___________________________________

✔ CHECK LIST FOR ELIGIBILITY CRITERIA ✔

Please check each applicable box to indicate eligibility of proposed stationary agricultural engine technology.

❑ The stationary agricultural engine is 50 horsepower or greater.

❑ The engine/technology is eligible for program funding.

Check applicable categories below:

The reduced-emission engine/technology:

- ❑ is certified for sale in California;

- ❑ meets the minimum NOx emission reduction requirement, with no increase in particulate matter emissions, compared to the applicable standards or emission levels for that engine year and type of application through:
  - ❑ California Air Resources Board (ARB) certification testing, or
  - ❑ U.S. EPA certification testing, or
  - ❑ Emission testing at a laboratory approved by the U.S. EPA or the ARB;

and

C. For agricultural pump repower projects:

- ❑ The replacement engine must be certified to the current emission standards applicable for that engine, and is at least 15 percent lower than the NOx, or NOx+NMHC, emission level of the engine being replaced, or
- ❑ is replaced with an electric motor

B. For retrofit kit or add-on projects:

- ❑ shows at least a 15 percent reduction of NOx, or NOx+NMHC, emissions, and no increase in particulate matter emissions, compared to the applicable standards or emission levels for that engine year.
- ❑ The retrofit technology is warranted by retrofit manufacturer and/or authorized dealer.

❑ The purchase is not required by any local, state, or federal rule or regulation, or used to comply with any such rule or regulation.

❑ The purchase is not required by any local, state, or federal Memorandum of Understanding (MOU) or Memorandum of Agreement (MOA).

❑ The amount of emission reduction is not required by any local, state, or federal MOU.

STATIONARY AGRICULTURAL ENGINE APPLICATION
Please Print or Type All Information on This and Any Attached Applications.

APPLICANT INFORMATION:		
Organization/Company Name:		
Business Type:		
Project Name:		
Street/Mailing Address:		
City:	State:	Zip Code:
Contact Name:		
Phone: ( )	Fax: ( )	
E-mail:		
Number of Stationary Agricultural Engines:		
Number of Stationary Agricultural Engines to be Replaced/Retrofitted:		

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

STATIONARY AGRICULTURAL ENGINE APPLICATION

Engine Repower or Retrofit Information

For each engine that you plan to repower/retrofit, complete and attach one copy of the appropriate form.

1. Company Name:	
2. Please Check One: □ Repowering a stationary agricultural engine with a new reduced-emission engine □ Retrofitting a stationary agricultural engine with a new reduced-emission technology	

A. Information About New Reduced-Emission or Retrofitted Engine:		
3. Engine Type: □ Compression Ignition □ Spark Ignition		
4. Engine Manufacturer:		
5. Engine Model:	6. Engine Series:	7. Engine Serial Number:
8. Manufacturer's Maximum Rated Brake Horsepower Rating:	9. Year of Manufacture:	
10. Primary Fuel: □ Diesel □ Natural Gas □ Other If "Other," specify fuel:		
11. Estimated Total Annual Hours of Operation:	12. Estimated Engine Operating Load (if known):	
13. Estimated Annual Fuel Consumption (include units):		
14. Primary Function of Engine (e.g., irrigation pump):		
15. Is there any seasonality to the use of the engine? YES/NO If Yes, please explain:		
16. Estimated Engine Life:	17. Estimated Rebuild/Replacement Schedule:	
18. Cost of Rebuilding/Replacing Engine:	19. Cost of Rebuilding/Replacing Engine with Low Emission Technology:	
20. Certified NOx Emission Standard:	21. Certified PM Emission Standard:	
22. Indicate certified engine United State Environmental Protection Agency Standardized Engine Family Name:		
23. Indicate the method of record keeping that will be used: □ Annual fuel use records □ Annual records of hours of operation as verified by non-reset hour meter installed on the engine		

STATIONARY AGRICULTURAL ENGINE APPLICATION

Engine Repower or Retrofit Information *(continued)*

B. Information About Existing Engine to be Repowered or Retrofitted:		
1. Engine Type: ☐ Compression Ignition ☐ Spark Ignition		
2. Engine Manufacturer:		
3. Engine Model:	4. Engine Series:	5. Engine Serial Number:
6. Manufacturer's Maximum Rated Brake Horsepower Rating:	7. Year of Manufacture:	
8. Primary Fuel: ☐ Diesel ☐ Natural Gas ☐ Other If "Other," specify fuel:		
9. Average Engine Life:	10. Typical Rebuild/Replacement Schedule:	
11. Cost of Rebuilding/Replacing Engine:		
12. Baseline NOx Emission Standard:	13. Baseline PM Emission Standard:	
14. Indicate certified engine United State Environmental Protection Agency or Air Resources Board Standardized Engine Family Name (if applicable):		

C. General Information About the Installer:		
Please complete the information below for engine repower (replacement)		
1. Engine Installer:		
2. Street Address:		
City	State:	Zip Code:
3. Contact Name:		
Phone: ( )	Fax: ( )	

Please complete the information below for engine retrofit		
4. Retrofit Manufacturer:		
5. Retrofit Installer:		
6. Installer Street Address:		
City	State:	Zip Code:
7. Contact Name:		
Phone: ( )	Fax: ( )	
8. Retrofit Kit Number:		
9. Description of Retrofit Technology:		

STATIONARY AGRICULTURAL ENGINE APPLICATION

New Pump with Electric Motor or Electric Motor Replacement Information

For each engine that you plan to add or replace, complete and attach one copy of the appropriate form.

1. Company Name:	
2. Please Check One: ☐ Replacing a stationary agricultural engine with an electric motor ☐ Purchasing a new agricultural pump powered by an electric motor	

A. Information About Existing Engine to be Replaced:		
3. Engine Type: ☐ Compression Ignition ☐ Spark Ignition		
4. Engine Manufacturer:		
5. Engine Model:	6. Engine Series:	7. Engine Serial Number:
8. Manufacturer's Maximum Rated Brake Horsepower Rating:	9. Year of Manufacturer:	
10. Primary Fuel: ☐ Diesel ☐ Natural Gas ☐ Other If "Other," specify fuel:		
11. Estimated Total Annual Hours of Operation:	12. Estimated Engine Operating Load:	
13. Estimated Annual Fuel Consumption (include units):		
14. Primary Function of Engine (e.g., irrigation pump):		
15. Is there any seasonality to the use of the engine? YES/NO If Yes, please explain:		
16. Average Engine Life:	17. Typical Rebuild/Replacement Schedule:	
18. Cost of Rebuilding/Replacing Engine:	19. Cost of Rebuilding/Replacing Engine with Low Emission Technology:	
20. Baseline NOx, or NOx+NMHC, Emission Standard:	21. Baseline PM Emission Standard:	
22. Indicate certified engine United State Environmental Protection Agency or Air Resources Board Standardized Engine Family Name (if applicable):		

B. Information About New Electric Motor:	
1. Electric Motor Manufacturer:	
2. Electric Motor Model:	3. Electric Motor Serial Number:
4. Estimated Total Annual Hours of Operation:	
5. Estimated Annual Energy Usage (include units):	
6. Estimated Electric Motor Life:	7. Estimated Rebuild/Replacement Schedule:
8. Cost of Replacing with Electric Motor:	
9. Indicate the method of record keeping that will be used: ☐ Annual power consumption records ☐ Annual records of hours of operation as verified by non-reset hour meter installed on the electric motor	

C. General Information About the Installer:		
1. Electric Motor Installer:		
2. Street Address:		
City	State:	Zip Code:
3. Contact name:		
Phone: ( )	Fax: ( )	

APPENDIX G

FORKLIFTS
PROJECT APPLICATION

Carl Moyer Memorial Air Standards Attainment Program
FORKLIFT PROJECT
APPLICATION

This application is for incentive funds to purchase a new electric forklift or retrofit an existing internal combustion engine forklift.

Please provide the following information regarding your proposed purchase or retrofit and application. Additional information may be requested during the review process, if needed. Applicant acknowledges that award of cash incentive is conditional upon approval of the District and must meet the minimum eligibility criteria.

Within ten working days of submission, you will either be notified that your application is complete, or provided with a list of deficiencies. Completed applications fulfilling the criteria will be approved within 60 working days of receipt. If you have any questions regarding the application process, please contact:

District Incentive Program Contact
Contact Phone Number

✔ CHECK LIST FOR APPLICATION ITEMS ✔

Be sure the following items are included with your application submittal. Check each applicable box below to indicate inclusion of material.

❏ Completed Applicant Information – Section A

❏ Completed Existing Fleet Information – Section B

❏ Completed New Equipment Information – Sections C through E (Electric Replacements Only)

❏ Completed Information About Existing Forklift Being Replaced – Section F

❏ Completed Forklift Information For Operation/Facility Expansion or New Facility – Section G (Electric Replacements Only)

✔ CHECK LIST FOR ELIGIBILITY CRITERIA ✔

Please check each applicable box to indicate eligibility of proposed forklift technology.

❏ The equipment is an electric forklift:

- ❏ Rated class 1 (lift code 5) four wheel sit-down counterbalanced model, cushion tire.

or

- ❏ Rated class 1 (lift code 6) four wheel sit-down counterbalanced model.

❏ The electric forklift is:

- ❏ Replacing an older non-electric forklift in existing business/fleet.

  or
- ❏ Part of business/fleet expansion.

  or
- ❏ For new facility or business.

❏ The electric forklift is rated:

- ❏ 3000 to 5999 pound lift capacity
- ❏ 6000 pound or greater lift capacity (for existing business/fleet).

❏ A battery charging unit for the electric forklift will be purchased (includes fast charger for multiple forklifts).

❏ The purchase is not required by any local, state, or federal rule or regulation, or used to comply with any such rule or regulation.

❏ The purchase is not required by any local, state, or federal Memoranda of Understanding (MOU), or Memoranda of Agreement (MOA), or any other binding agreement.

❏ The amount of emission reduction is not required by any local, state, or federal MOU, or MOA, or any other binding agreement.

❏ Seventy five percent or more of the equipment fuel consumption or hours of operation will be within the boundaries of the district, or within California, for at least (5) years from the date the equipment is placed into service.

✔ CHECK LIST FOR ICE RETROFIT ELIGIBILITY CRITERIA ✔

Please check each applicable box to indicate eligibility of proposed forklift technology.

❏ The equipment is an internal combustion engine forklift:

- ❏ Rated Class 4 - Rider, sit down, generally suitable for indoor use on hard surfaces, or
- ❏ Rated Class 5 - Rider, sit down, typically used outdoors, on rough surfaces or steep inclines, or
- ❏ Rated Class 7 - Rough terrain LSI engine forklift truck for outdoor use.

❏ The retrofit is not required by any local, state, or federal rule or regulation, or used to comply with any such rule or regulation.

❏ The retrofit is not required by any local, state, or federal Memoranda of Understanding (MOU), or Memoranda of Agreement (MOA), or any other binding agreement.

❏ The amount of emission reduction is not required by any local, state, or federal MOU, or MOA, or any other binding agreement.

❏ Seventy five percent or more of the equipment fuel consumption or hurs of operation will be within the boundaries of the district, or within California, for at least (5) years from the date the equipment is placed into service .

FORKLIFT APPLICATION

A. APPLICANT INFORMATION:		
Organization/Company Name:		
Business Type:		
Project Name:		
Contact name/title:		
Person with contract signing authority:		
Street/mailing address:		
City:	State:	Zip code:
Phone: ( )	Fax: ( )	
E-mail:		
Current operation/facility size (square feet):	Expanded operation/facility size (square feet):	
Geographic area served by organization:		
Geographic area to be served by equipment (if different than above):		

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

EQUIPMENT INFORMATION

B. EXISTING FLEET INFORMATION (Please fill out if you are retrofitting or replacing a non-electric forklift in your current fleet/business or if this is a proposed purchase for fleet/business expansion. If you are a new facility/business, please continue to Part C.)
1. Number of forklifts in applicant's existing fleet:
2. Number of non-electric forklifts in the applicant's current fleet:
3. Business or industry of applicant:
4. Does the applicant rent or lease forklifts to other parties?
5. Routine work application of current forklift fleet:
6. Is the current forklift fleet generally used inside or outside?
7. Number of forklifts in existing fleet that are currently used on rough terrain, or inclines greater than 10 percent?
8. Does the applicant currently own or lease charging equipment?

NEW EQUIPMENT INFORMATION
(Retrofit applicants please continue to Part F.)

C. GENERAL INFORMATION ABOUT NEW EQUIPMENT PURCHASED, LEASED TO OWN, OR CONSIDERED FOR PURCHASE OR LEASE TO OWN (To be filled out by all electric replacement applicants)	
9. Number of electric forklifts, rated Class I (lift code 5 or 6) purchased or considered for purchase?	
10. Do you intend to purchase more than one battery pack for each forklift?	
11. Number of chargers purchased or considered for purchase?	
12. Will the forklifts be used primarily inside or outside?	
13. Primary function or work application of equipment:	
14a. Estimated total annual hours of operation:	14b. Percent within district boundaries:
15a. Estimated annual electrical consumption for each forklift (kilowatt hours):	15b. Percent within district boundaries (*if applicable):*

NEW EQUIPMENT INFORMATION (CONTINUED)

16. Describe how, and where the forklift(s) will be charged: (*for example, charge forklift overnight or when not in use, or fast charge multiple forklifts, or remove batteries from forklift to charge & replace with charged battery packs for multiple shift operations).*

D. NEW ELECTRIC FORKLIFT EQUIPMENT PURCHASED OR CONSIDERED FOR PURCHASE (All applicants please fill out for each forklift purchased or considered for purchase)	
17. Equipment make:	
18. Equipment model:	
19. Equipment model year:	
20. Lift capacity (pounds) for each forklift:	
21. What is the forklift class and lift code rating?	
22. What kind of tires does the forklift have (air-filled, cushion, other)?	
23a. Estimated replacement schedule:	23b. Project Life (do not include range)
24. Cost of new electric forklift (do not include battery pack):	
25. Cost of one battery pack:	

MANUFACTURER OR DEALER INFORMATION

E. MANUFACTURER OR DEALER INFORMATION (To be filled out by all applicants):	
Manufacture/Dealer:	
Street Address:	
City:	State:
Phone: ( )	Fax: ( )
Contact Name:	

FORKLIFT REPLACEMENT INFORMATION

F. INFORMATION ABOUT EXISTING FORKLIFT BEING REPLACED OR RETROFITTED (Fill out if you are replacing or retrofitting a non-electric forklift in your existing fleet. If you are expanding your current fleet/business or are a new facility/business, go to Part G.):		
26. Forklift manufacturer:		
27. Forklift model & serial number:	28. Year purchased:	29. Year manufactured:
30. Manufacturer's Maximum Rated Brake Horsepower Rating: *(if known)*	31. Lift capacity (pounds) for each forklift:	
32. Estimated annual fuel consumption (include units):	33. Estimated total annual hours of operation:	
34. How many years do you typically use your forklifts?	35. Estimated cost of replacing equipment:	
36. Primary Fuel: ☐ Diesel ☐ Propane ☐ Gasoline		
37. Primary function (work application) of forklift:		
38. Briefly describe what you intend to do with this forklift after you have purchased the new electric forklift:		

INFORMATION ON FORKLIFTS USED FOR OPERATION/FACILITY EXPANSION OR NEW FACILITY
(Retrofit applicants need not complete Part G.)

<table>
<tr><td colspan="4">G. INFORMATION ON THE NON-ELECTRIC FORKLIFT THAT YOU WOULD HAVE PURCHASED IF YOU DID NOT RECEIVE FUNDING FROM THE CARL MOYER PROGRAM (Fill out if you are expanding your current operation/facility or are a new operation/facility):</td></tr>
<tr><td colspan="4">39. Forklift manufacturer:</td></tr>
<tr><td>40. Forklift model:</td><td colspan="2">41. Lift Capacity for each forklift (in pounds):</td><td>42. Year manufactured:</td></tr>
<tr><td colspan="2">43. Manufacturer’s Maximum Rated Brake Horsepower Rating:</td><td colspan="2">44. Cost if purchased new:</td></tr>
<tr><td colspan="2">45. Estimated annual fuel consumption (include units):</td><td colspan="2">46. Estimated total annual hours of operation:</td></tr>
<tr><td colspan="4">47. Primary Fuel: ☐ Diesel ☐ Propane ☐ Gasoline</td></tr>
<tr><td colspan="4">48. Name and Phone Number of Store or Dealer where you would have purchased the forklift:</td></tr>
</table>

APPENDIX H

AIRPORT GROUND SUPPORT EQUIPMENT
PROJECT APPLICATION

Carl Moyer Memorial Air Standards Attainment Program
ELECTRIC GROUND SUPPORT EQUIPMENT
APPLICATION

This application is to be used for incentive funds for the purchase of new electric ground support equipment (GSE).

Please provide the following information regarding your proposed purchase and application. Additional information may be requested during the review process if needed. Applicant acknowledges that award of cash incentive is conditional upon approval of the District and must meet the minimum eligibility criteria.

Within ten working days of submission, you will either be notified that your application is complete, or provided with a list of deficiencies. Completed applications fulfilling the criteria will be approved within 60 working days of receipt. If you have any questions regarding the application process, please contact:

District Incentive Program Contact
Contact Phone Number

✔ CHECK LIST FOR APPLICATION ITEMS ✔

Be sure the following items are included with your application submittal. Check each applicable box below to indicate inclusion of material.

- ❏ Completed Application Information – Section A
- ❏ Completed Information for Existing GSE to be Replaced – Section B through C
- ❏ Completed Information About Each New Electric GSE Purchased or Considered for Purchase – Section D
- ❏ Completed Information for New or Expanding Fleets – Section E

✔ <u>CHECK LIST FOR ELIGIBILITY CRITERIA</u> ✔

Please check each applicable box to indicate eligibility of proposed electric GSE equipment:

❑ The GSE equipment being replaced is 50 horsepower or greater.

❑ New electric GSE equipment of the following type has been (or being considered for) purchased:

  ❑ Belt loader, baggage tug, cargo loader, aircraft tug, lift, or ground power unit.

❑ The GSE will not be operated at the following airports: LAX, Ontario, Orange County, Burbank or Long Beach.

❑ The new electric GSE equipment will not be leased or rented to another business or organization.

❑ The purchase is not required by any local, state, or federal rule or regulation, or used to comply with any such rule or regulation.

❑ The purchase is not required by any local, state, or federal Memorandum of Understanding (MOU) or Memorandum of Agreement (MOA) or any other binding agreement (such as air quality certificate requirements).

❑ The amount of emission reduction is not required by any local, state, or federal MOU, or any other binding agreements or requirements.

❑ ELECTRIC GSE PROJECT APPLICATION

Please Print or Type All Information on This and Any Attached Applications.

A. APPLICANT INFORMATION:		
Organization/Company Name:		
Project Name:		
Business Type: (airport operator, airline, fixed base operator, or equipment management company, etc)		
Street/Mailing Address:		
City:	State:	Zip Code:
Contact Name:		
Phone: ( )	Fax: ( )	
E-mail:		
California airport where GSE will be operated:		

I hereby certify that all information provided in this application and any attachments are true and correct.

Printed Name of Responsible Party:	Title:
Signature of Responsible Party:	Date:

EXISTING GSE INFORMATION

For each piece of equipment that you plan to replace, complete and attach one copy of the appropriate section.

<table>
<tr><td colspan="6">B. INFORMATION ABOUT EXISTING GSE EQUIPMENT TO BE REPLACED</td></tr>
<tr><td colspan="6">1. Equipment Operator: (airport, airline, equipment management company, etc.)</td></tr>
<tr><td colspan="6">2. Equipment Type:</td></tr>
<tr><td colspan="6">3. Engine Type: ☐ Compression Ignition ☐ Spark Ignition</td></tr>
<tr><td colspan="6">4. Equipment Manufacturer:</td></tr>
<tr><td colspan="2">5. Engine Model:</td><td colspan="2">6. Engine Series:</td><td colspan="2">7. Engine Serial Number</td></tr>
<tr><td colspan="2">8. Manufacturer’s Maximum Rated Brake Horsepower Rating:</td><td colspan="2">9. Year Purchased</td><td colspan="2">10. Model Year:</td></tr>
<tr><td colspan="6">11. Primary Fuel: ☐ Diesel ☐ Natural Gas ☐ Other If “Other,” specify fuel:</td></tr>
<tr><td colspan="3">12. Estimated Total Annual Hours of Operation:</td><td colspan="3">13. Estimated Engine Operating Load (if known)</td></tr>
<tr><td colspan="6">14. Airport that Equipment Operated:</td></tr>
<tr><td colspan="6">15. Percent Equipment Operated in California:</td></tr>
<tr><td colspan="3">16. Average Equipment Life (total hours):</td><td colspan="3">17. Typical Replacement Schedule:</td></tr>
<tr><td colspan="6">18. Cost of Replacing with new Equipment: $</td></tr>
<tr><td colspan="3">19. Baseline NOx+NMHC Emission Level (g/bhp-hr):</td><td colspan="3">20. Baseline PM Emission Level (g/bhp-hr):</td></tr>
<tr><td colspan="6">21. Indicate certified engine United State Environmental Protection Agency or Air Resources Board Standardized Engine Family Name (if applicable):</td></tr>
</table>

C. Briefly describe what do you plan to do with equipment that is being replaced

NEW GSE INFORMATION

For each piece of equipment that you plan to purchase, complete and attach one copy of the appropriate section.

D. INFORMATION ABOUT NEW ELECTRIC MOTOR	
8. Type of Equipment (i.e. belt loader, aircraft tug, etc):	
2. Number of Equipment Pieces:	
9. Equipment Manufacturer:	
10. Electric GSE Model:	5. Electric Motor Serial Number:
11. Estimated Total Annual Hours of Operation:	
12. Airport at which equipment will be operated:	
13. Cost of Equipment:	14. Cost of battery pack (if not included in #7)
10. Estimated Useful Equipment Life (hours):	
11. Indicate the method of recordkeeping that will be used: ☐ Annual power consumption records ☐ Annual records of hours of operation as verified by non-resettable hour meter installed on the electric motor	

FLEET EXPANSION OR NEW BUSINESS

FLEET EXPANSION (If you are expanding your fleet, please provide information on the GSE Equipment You Would Have Purchased had not incentive funds been available.):	
1. Equipment Type:	
2. Number of Equipment:	
3. Engine Type: ☐ Compression Ignition ☐ Spark Ignition	
4. Equipment Manufacturer:	
5. Engine Model:	6. Model Year:
7. Manufacturer's Maximum Rated Brake Horsepower Rating:	
8. Cost of New GSE Equipment:	
9. Primary Fuel: ☐ Diesel ☐ Natural Gas ☐ Other If "Other," specify fuel:	